Grand River Simulation Model

User Manual

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Grand River Conservation Authority

Region of Waterloo

Revision History

Date (yyyy/mm/dd)	Change	Acknowledgments
2011-01-06	Final version for publication	Stantec

Preface

The Grand River Simulation Model (GRSM) is a water quality model of the Grand River applied by scientists, engineers, and planning staff to understand how proposed changes to a watershed might affect the quality of water in the rivers. The GRSM is is a versatile model that can be adapted to other watersheds. This flexibility rests in the fact that all the simulation parameters can be updated based on the unique characteristics of the different watersheds.

The GRSM focuses on dissolved oxygen (DO) as the most important indicator of river water quality because DO levels play a large role in determining the level of stress on fish communities and diversity of the fishery in the river. Since DO levels are significantly affected by discharge of treated wastewater to the river, they are good indicators of the impact of wastewater discharges on the river environment. The GRSM also models biochemical oxygen demand, nitrogenous oxygen demand, nitrate, suspended solids and total phosphorus.

History

1970

The Ministry of the Environment (MOE) and the Grand River Conservation Authority (GRCA) developed the GRSM in the 1970s. It built on similar work that had been done in Southwestern Ontario, in which a dynamic simulation model was used to evaluate strategies to control eutrophication in the Thames River. The Grand River Implementation Committee used the GRSM in 1982 to evaluate water management options for the Grand River Basin Water Management Study.

1980

Aside from the initial development period, the GRSM remained unused for a number of years, until the issue of increased waste water treatment plant (WWTP) discharges was raised by the MOE and several municipalities in the early 1990s. Urban development in Guelph and the Regional Municipality of Waterloo led to plans for WWTP expansion.

1990

In the mid 1990s, the model underwent a major upgrade to overcome limitations due to hardware and software constraints. The new version had a more streamlined input and output process. Subsequently, the equations describing plant growth and inhibition were reviewed and in some cases revised, to improve the model's consistency with recent research and to bring calibrated oxygen minima closer to observed levels.

2000

As part of the Middle-Grand River Assimilative Capacity Study completed in 2010 by Stantec Consulting Ltd. (Stantec) for the Region of Waterloo, ammonia volatilization and denitrification were incorporated in the GRSM to provide a more comprehensive picture of important nitrogen cycle processes occurring in the Grand River. Stantec also updated and consolidated the GRSM user documentation to reflect the changes that have been made to the model over the years.

2010

The improvements and modifications that have been made to the GRSM since its inception are a testament to its adaptability and versatility.

Acknowledgements

This User Manual was designed and developed with financial contributions from the Region of Waterloo.

The writers wish to expression their appreciation to the staff of the Grand River Conservation Authority for their technical advice and assistance during the development of this documentation.

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1. Introduction

This User Manual provides the information required to install, execute, and troubleshoot the Grand River Simulation Model (GRSM).

1.1. The Grand River Simulation Model (GRSM)

The GRSM is a dynamic (non-steady state), one-dimensional water quality model that enables users to study the impacts of alternative water management strategies on nutrients and dissolved oxygen concentrations in a river. Although the GRSM is currently applied to the Grand River watershed, it is a versatile model that can be adapted to other watersheds. This flexibility rests in the fact that all the simulation parameters can be updated based on the unique characteristics of the different watersheds.

As a complex mathematical computer simulation model, the GRSM can simulate up to 10 water quality parameters and three aquatic plant species for a period of up to 25 years, using a finite time step of two hours. The GRSM can incorporate input from up to 30 point sources, such as wastewater treatment plants, urban catchments (maximum 30), tributaries (maximum 100) and water withdrawal sites (maximum 100). The GRSM can also incorporate information generated by other hydraulic models, such as loading from rural diffuse runoff and groundwater inflow.

The water quality parameters presently simulated are:

- Dissolved oxygen (DO)
- Carbonaceous biochemical oxygen demand (CBOD)
- Nitrogenous oxygen demand (NOD)
- Nitrate (NIT)
- Suspended solids (SS)
- Total phosphorus (TP)
- Un-ionized ammonia (UIA*)
  **Although not directly modelled as a state variable, UIA is estimated from the simulation results based on temperature, pH and background organic nitrogen concentrations.*

No other available model simulates species-specific plant/algae growth dynamics as GRSM does. The three aquatic plant species modeled in the GRSM are *Cladophora glomerata*, *Potamogeton pectinatus* (note: this species was renamed *Stuckenia pectinata*, however for consistency with previous documentation it will be referred to in this document simply as *Potamogeton*), and *Myriophyllum spicatum* (which replaced periphyton in 1995). These species' daily growth and processes of photosynthesis and respiration are modeled to determine the impacts of aquatic vegetation upon nutrients and DO.

The GRSM is composed of a linked series of sub-models that replicate the many chemical, biochemical and biological processes occurring within the river system. The river system is visualized as a series of reaches connected by node points. Each reach is a small section of the river that exhibits uniform physical, hydraulic and waste assimilative characteristics. The model takes into account the effects of BOD and NOD decay, weir aeration and atmospheric reaeration, sediment oxygen demand and the rates of photosynthesis and respiration of aquatic plant communities. In 2010, ammonia volatilization and denitrification were incorporated in the GRSM to provide a more comprehensive picture of the important nitrogen cycle processes occurring in the Grand River.

At each of the node points, flows from consecutive reaches are added or split according to the geometry of the systems. Point source inflows, local diffuse inflows and urban stormwater inflows are input and mixed at the appropriate nodes for each time step during the simulation. The water quality for each of the parameters modeled for each inflow is either calculated by individual sub-models or read in the external system data files. Mixing and decay processes are allowed to occur as the water is routed through each reach, thereby yielding the instream water quality at any river location at each simulation time step.

The simulation repeats the above process for each time step for each day of the specified portion of the year. To further account for the random factors in the natural system, simulation of the specified portion of the year can be repeated on another set of conditions by utilizing the multi-year simulation option.

Since the GRSM simulates processes that are affected by the degree of solar radiation, different chemical, biochemical, and biological processes will dominate depending on the time of day. Figure 1 illustrates the processes that dominate in the daytime, whereas Figure 2 illustrates the processes that dominate in the nighttime.

Figure 1: Daytime Dominant Processes (Temperature Dependent)

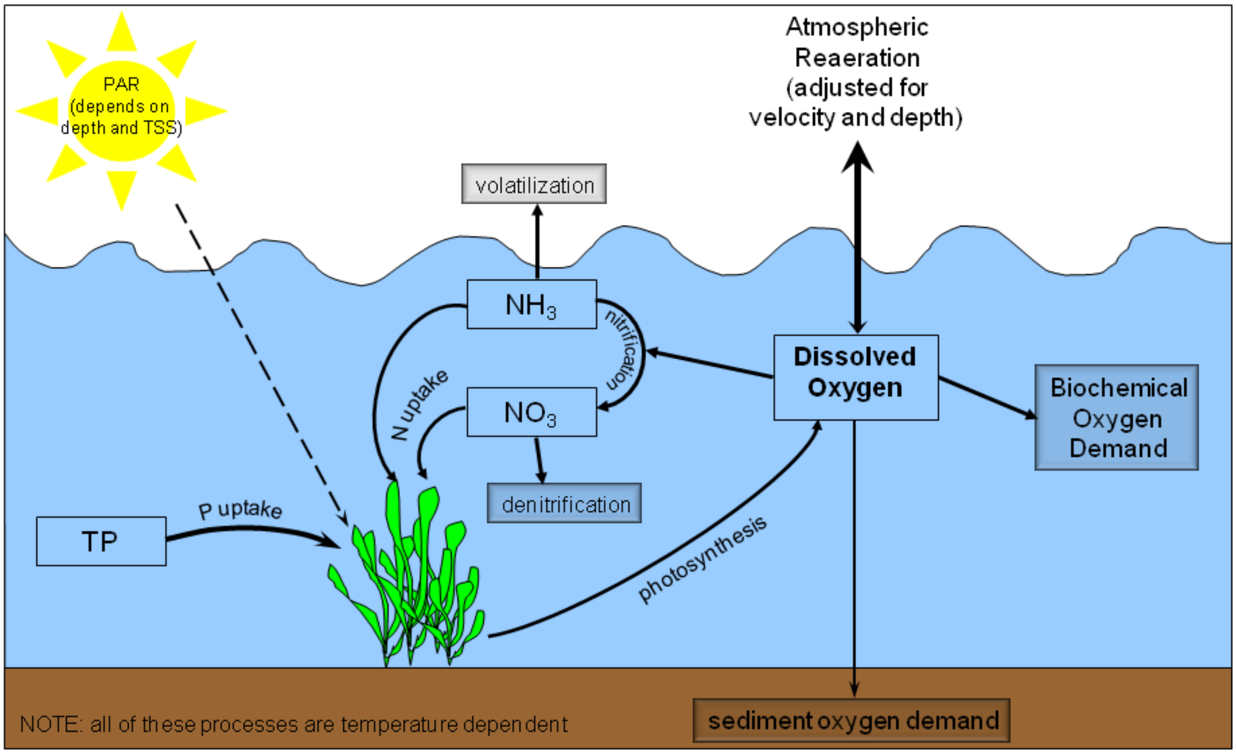
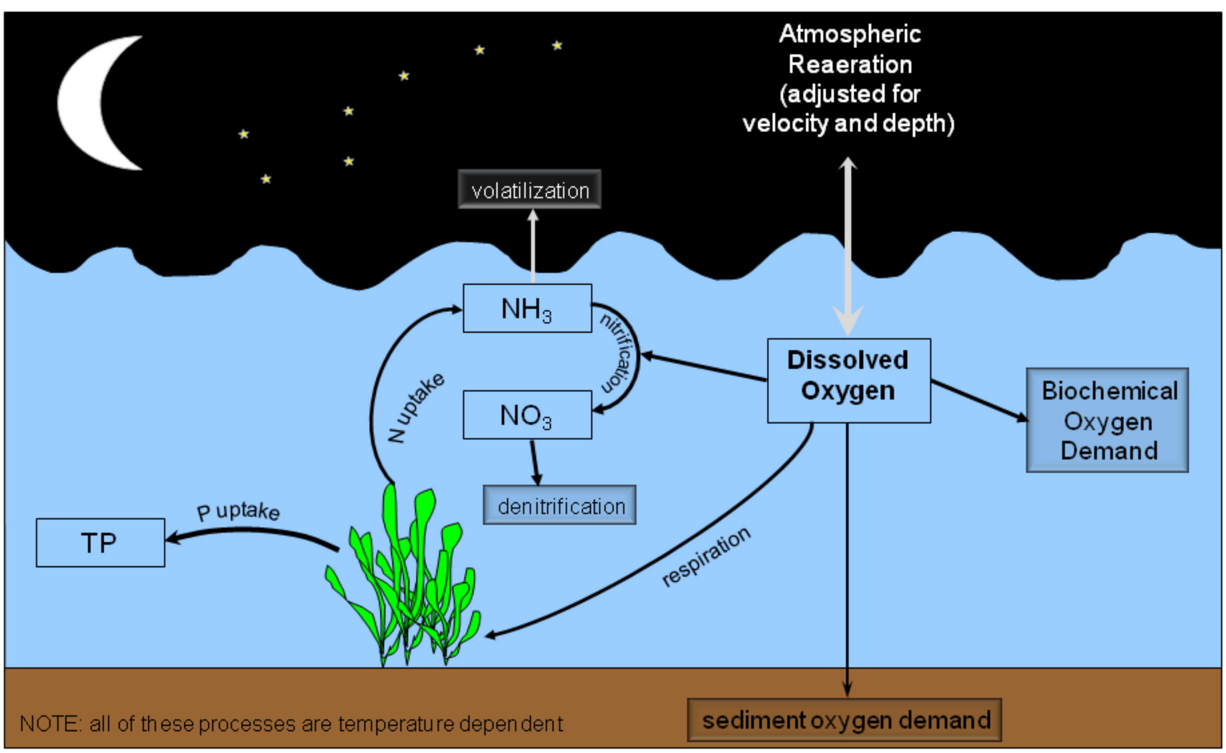


Figure 2: Nighttime Dominant Processes (Temperature Dependent)



Introduction

1.2. Grand River Conservation Authority License Agreement

A copy of the Grand River Conservation Authority (GRCA) License Agreement (“License”) is available online, through the GRCA’s website:

http://www.grandriver.ca/grsm

Before using the GRSM, you will have to read and agree to the License Agreement.

1.3. Intended Users

This User Manual was written for consultants, municipal employees, agents, and/or researchers studying the effect of effluents on river systems dominated by the types of the aquatic plants simulated by the GRSM (e.g., *Cladophora glomerata*, *Potamogeton pectinatus*, and *Myriophyllum spicatum*). It is assumed that the user is familiar with computer operation and with determination of the data required for running large, complex water quality simulation models.

1.4. User Manual Scope and Purpose

This User Manual is designed to provide a step-by-step procedure for using the GRSM. The document is divided into several sections to facilitate its use as a reference document for the required input parameters. Detailed descriptions of the major variables are also included as appendices.

1.5. Conventions Used in this Document

Throughout this User Manual, symbols are used to highlight important information. Table 1 shows each symbol and describes the context in which it will be used.

Table 1: Description of symbols

Symbol	Description
	This symbol is placed beside important notices regarding the data entered in the GRSM input files. Follow these tips to prevent errors while executing the model.
	This symbol is placed beside suggested best practices. Follow these proposed tips to more effectively enter data in the GRSM input files.

1.6. Technical Guidance Document

For additional information regarding the theory behind the input parameters and the subroutines, please refer to the GRSM Technical Guidance Document, available under separate cover.

2. Glossary

2.1. Common Terms

Block: Refers to a specific section of an input file for GRSM. This document describes the structure and content of each input file and identifies the blocks that make up each file.

Boundary Flow: Major tributary entering the model domain. Where possible, model input for each boundary flow is based on daily average measured flow at the nearest flow gauge.

Local Diffuse Inflow: All flow inputs into the model domain other than the boundary flow. Accounts for small tributaries, local drainage and groundwater. Use daily average flows for the entire model domain.

Model Domain: The portion of the river system that is being modeled. The model domain is divided into reaches that are connected together to form a river network.

Node: Connecting point between two reaches.

Point Source: Wastewater treatment plant effluent discharged to the river system.

Probability Distribution: For the purposes of GRSM, probability distributions are expressed as a series of 11 numbers representing the range of values that a parameter may have. The 11 numbers are the minimum, 10th percentile, 20th percentile, 30th percentile, etc. up to the maximum value for that parameter.

Reach: A small section of the river which exhibits uniform physical, hydraulic, and waste assimilative characteristics. The river system to be simulated is visualized as a series of reaches connected by nodes.

2.2. Acronyms

CBOD	Carbonaceous biochemical oxygen demand
cfs	Cubic feet per second
CLAD	*Cladophora glomerata*
cms	Cubic metres per second
DO	Dissolved oxygen
GRCA	Grand River Conservation Authority
GRSM	Grand River Simulation Model
LDI	Local diffuse inflow
MIL	*Myriophyllum spicatum*, commonly known as *Eurasian milfoil*
NIT	Nitrate (also shown as NO_3)
NOD	Nitrogenous oxygen demand
PAR	Photosynthetically available radiation
POT	*Potamogeton pectinatus*, commonly known as Sago pondweed. Note: this species was renamed *Stuckenia pectinata*; the two names are synonymous
SOD	Sediment oxygen demand
SS	Suspended solids
TP	Total phosphorus
UIA	Un-ionized ammonia
VBGI	Visual Basics Graphics Interface
WWTP	Wastewater treatment plant

3. Installation

3.1. Minimum System Requirements

The GRSM executes in a batch control mode in either the DOS environment or the Visual Basics Graphics Interface (VBGI) environment.

A spreadsheet application such as Microsoft Office Excel (MS Excel) is recommended to extract useful information from the output files generated by GRSM execution.

3.2. Locating the GRSM

Details on how to obtain a copy of the GRSM are available online, at:

http://www.grandriver.ca/grsm

3.3. Executing the GRSM

After acquiring a copy of the GRSM, you may use the model by following the steps described below.

1. Extract the content of **GRSM.ZIP** to C:\.
2. Where appropriate, update the information in all the input files.
    - Refer to pages 9 to 72 of this User Manual for guidance on updating information in the GRSM input files.
3. In C:\GRSM, double-click the file **GRSM.BAT**.
    - A DOS window will appear and you will see the model run through the different batch processes. Once the model execution is complete, the DOS window will close.
4. Analyse the data in the five output files.
    - Refer to pages 72 to 78 of this User Manual for guidance on how to analyse the date in the GRSM output files.

Keep folder names to less than eight characters to ensure the model executes properly.

4. Execution

The GRSM is a very complex model and has a correspondingly complex set of input requirements. However, the complexity of the input requirements is proportional to the conditions of the simulation you specify. The quantity of data required is also governed by the specific time frame of the simulation: the longer the specified simulation, the greater the quantity of required input data.

For a case study showing how to work through a GRSM simulation, refer to **Appendix A: Worked Example**.

4.1. Before Executing the GRSM

Before executing the GRSM, ensure the following information is readily available.

- **Definition of each reach.** The river must be divided into reaches, and the basic geometry and hydraulic characteristics must be determined. Locations of boundary (tributary) inflows, point source inflows and urban stormwater inflows must be identified relative to the defined reaches. The river must be defined within the constraints of a maximum of 100 reaches, 30 point source inflows and 30 urban stormwater inflows.

- **Hydrological data for all inflow points.** Data on boundary inflows and local diffuse inflows (LDI) are required for each inflow. Daily average flow data are required for each day of the simulation, preferably based on continuously measured flows. The model must have at least one boundary inflow, but it is possible to have as many as one boundary inflow per reach (e.g., a maximum of 100 boundary inflows).

- **Boundary inflow water quality data.** These data are required for each water quality parameter (DO, BOD, NOD, NIT, SS, and TP) for each identified tributary. Water quality data are entered as a probabilty function based on all available data.

- **Point source inflow.** Data on the quality and quantity of each point source (e.g WWTPs) are required. Flow data are input for each day of simulation. Effluent quality is expressed as a probability distribution.

- **Local diffuse inflow quality.** Data on the quality of the diffuse inflow are required for each time step and for each day of simulation.

- **Urban storm inflow.** Data on the water quality and quantity for each urban stormwater inflow are required for each stormwater input, for each time step (12 per day) and for each day of the simulation. Inclusion of urban storm flows is optional.

- **Meteorologic conditions.** Data on sunlight is required for each day of the specified simulation period. Water temperature is entered for each time step of each day of the simulation for each reach, ideally based on continuous monitoring data.

For a complete list of data required to execute the GRSM, refer to **Appendix B: Input Parameters**.

4.2. What the GRSM Does

The GRSM simulates carbonaceous and nitrogenous biochemical oxygen demand, nitrate, suspended solids, total phosphorus, un-ionized ammonia, and dissolved oxygen. It models three species of aquatic plants, *Cladophora glomerata*, *Potamogeton pectinatus*, and *Myriophyllum spicatum*.

The GRSM also models ammonia volatilization and denitrification.

4.3. What the GRSM Does Not Do

The GRSM does not simulate phytoplankton (i.e., floating algae) as they are not considered to be a dominant influence in the Grand River watershed.

The model is not a hydraulic or hydrologic model; therefore the flow and quality coming into each reach from tributaries, groundwater, urban and rural non-point source runoff must be specified.

It is not a suitable tool for simulating highly variable wet weather sources such as non-point source runoff from urban or agricultural areas where flows may vary widely within a 24-hour period.

4.4. Input Files

The program uses four main input files (also known as “control files”) consisting of data partitioned by environmental processes, one input file of the river flows and three optional files containing supplementary data. The names of the files used by the model are listed in the FILENAME.DAT file where you can modify file names for executing various scenarios and keep important output separate for later post-processing.

Do not change the order of the files in FILENAME.DAT.

An example of the FILENAME.DAT is shown in Figure 3.

Figure 3: Example of FILENAME.DAT

```
2007 1           Expanded GRSM code v8.3 Summer 2007
I/O Unit         File name                                       Unit
       5         C:\GRSM\global\MAIN07su.mpf                     MAINFILE
      30         C:\GRSM\global\KACSrt.DAT                       RATEFILE
      40         C:\GRSM\global\BNDRYsu.QUA                      FLOWFILE
      80         C:\GRSM\global\STPsu.QUA                        STPFLOW
      99         BND07su.FLO                                     BASINFLOW
      66         GRSM.OUT                                        OUTPUT
      98         NOCHNG.MOD                                      PDFMOD
      81         STP07su.FLO                                     STP_FLOW_FILE
      70         FERG07su.STM                                    STORM1
      71         ELOR07su.STM                                    STORM2
      72         wtlo07su.STM                                    STORM3
      73         KITC07su.STM                                    STORM4
      74         GUEL07su.STM                                    STORM5
      75         CAMB07su.STM                                    STORM6
      76         PARS07su.STM                                    STORM7
      77         BRAN07su.STM                                    STORM8
      82         2007su.MET                                      METDATA
```

The FILENAME.DAT file is a simple ASCII file that can be edited with any text editor that does not insert hidden characters in the file. The editor provided with DOS or VBGI is suitable for modifying the contents of the file.

The first line of the FILENAME.DAT file contains a 4 digit integer that defines the simulation year followed by one blank space and a 2 digit integer that defines the simulation run number. All other text on this line is ignored by GRSM and can be used for user's reference information. The second line of FILENAME.DAT is a dummy line that is ignored by the model and contains the column headings for the rest of the file.

The input/output file unit number should not be changed and can be used for troubleshooting error messages given by GRSM. This number must occur in columns 7 and 8. The path and filename for each input file must start in column 18 and cannot be longer than 37 characters (e.g., cannot extend past column 55).

BYPASS.DAT contains a number of true/false flags for the various subroutines used in GRSM. An example of the BYPASS.DAT is shown in Figure 4. Setting the flag to F (false) means the model will skip that subroutine. The default value is T (true) for all subroutines.

Figure 4: Example of BYPASS.DAT

```
T              CALL  INDFLO
T              CALL  STPFLO
T              CALL  STORM
T              CALL  DEPFLO
T              CALL  ROUTNG
T              CALL  AVGFLO
T              CALL  SUNINT
T              CALL  STRPRM
T              CALL  QUAL11
T              CALL  QUAL12
T              CALL  QUAL13
T              CALL  PHOSYN
```

The **control data files** (MAINFILE, RATEFILE, FLOWFILE, and STPFLOW) are the most important of all the input files required to execute the GRSM. These files define the type of simulation desired as well as the exact geometry of the system to be simulated. It is within this data set that you select and define the options for execution. Depending upon the options selected, these files also include a major portion of the required input quality and quantity data.

Execution

The **required time series** input of river boundary flows is contained in BASINFLOW.

Optional input files include STP_FLOW_FILE, STORM, and METDATA. Note that these files are optional based on the internal/external switches in the BASICS block of MAINFILE (see below).

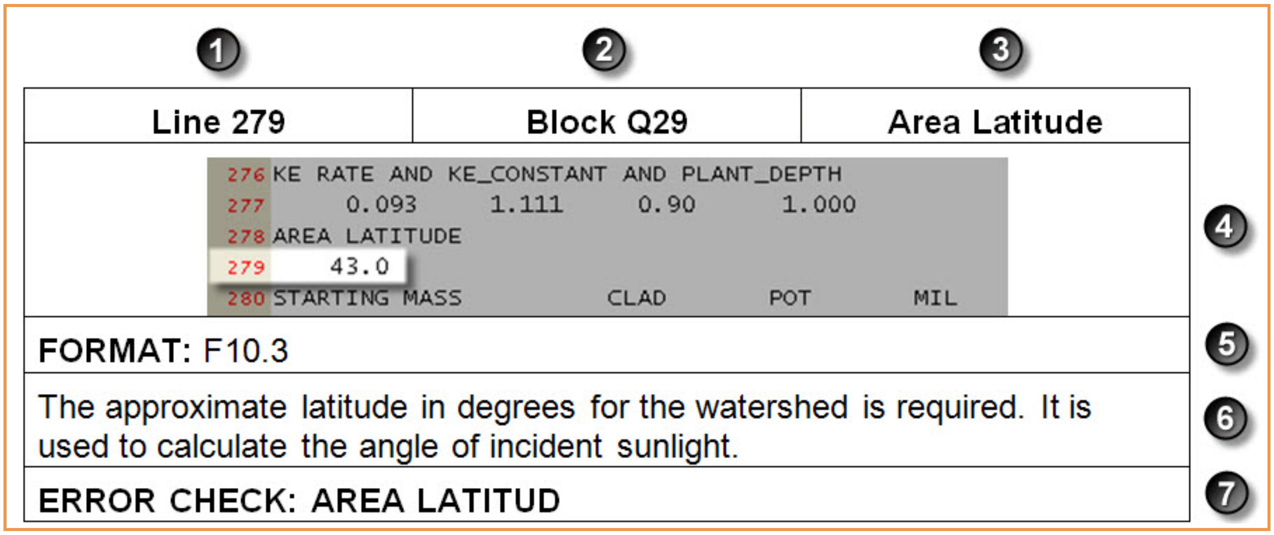
You only need to make changes to one or two files to simulate different execution and input alternatives. The STPFLOW control data file and the STP_FLOW_FILE are generally where most changes are made after model calibration and verification has been completed to simulate scenarios related to future changes in point source effluent quality or quantity. For example, to consider the impact of population growth or WWTP upgrades on river water quality.

The sections that follow define the content of each input file, any format restrictions that might apply to the data and error checks embedded within the input files.

4.4.1. Overview

Descriptions of the input files are contained within a standardized table, as illustrated in Figure 5.

Figure 5: Sample description of an input file



1. The first cell in the top row serves as a reference point, as it shows you which lines from the input file are being described.

This User Manual shows screenshots that were taken from the input files discussed in Appendix A. Keep in mind that if you change the number of reaches, boundaries, and/or point sources in your GRSM simulation, the number of lines in your input files will change and differ from the screenshots included in this User Manual.

Since the GRSM executes in a DOS or VBGI environment, you must enter data in the input files via simple text editors that do not insert hidden characters in a file, such as Notepad. You may find it helpful to see line numbers as you are working in your input files. Notepad will not display line numbers, but you may choose to download and install free text editors that will display line numbers on the left margin from one of the following online resources:

- Notepad2: http://www.flos-freeware.ch/notepad2.html
- Programmer's Notepad: http://www.pnotepad.org/

2. The second cell in the top row identifies the block number that is being described. A block contains all the information relating to one particular set of data within the input file. Blocks are sometimes further divided into sub-blocks to facilitate data input and characterization.
3. The third cell in the top row provides a brief description of the block.

4. The second row shows a screenshot of the input file taken in Notepad2 (note the line numbers on the left). The portion of the screenshot that is not greyed out illustrates the part of the input file that is being described.
5. The third row defines any format restrictions that might apply to the data that are entered in this block. You may encounter four types of format:
    a. **Free.** Alphanumeric characters may be used. There is no restriction on length. A space or comma is required to separate individual numbers.
    b. **X.** Blank space required. For example, 20X indicates that the GRSM is expecting 20 blank spaces.
    c. **F.** Real number required. A real number must include a decimal point, with a specified number of numeric characters after the decimal point (as defined in the format line). For example, 12F10.3 indicates that the GRSM is expecting 12 real numbers with 10 numeric characters. Of these 10 numeric characters, a maximum of three must be after the decimal point. Since the decimal point counts as one numeric character, the GRSM expects only six numeric characters to appear left of the decimal point.
    d. **I.** Integer required. An integer is a whole number, without decimals. For example, 17I3 indicates that the GRSM is expecting 17 integers each comprised of three digits.

If an integer does not require three digits (e.g., 24), replace the extra number with a blank space. Insert the blank space on the left of the integer.

6. The fourth row provides a detailed description of this section of the input file.
7. The fifth row provides information regarding any error checks that may be embedded within the input file. The input files contain specific pieces of text between sections of input values, which the GRSM expects to see (in this example, AREA LATITUD). If the GRSM does not read the expected piece of text, it produces an error which will help you determine where it is encoutering problems.

4.4.2. Templates

Working in a simple text editor can be difficult because the data are grouped so closely together. To address this concern and help create more accurate input files, the GRCA has prepared MS Excel templates in which you can enter your data. Once you have entered all the required data in the templates, you can save them as space-delimited text-only files and then copy and paste the data directly in the GRSM input files. Table 2 lists the templates that have been developed for the GRSM input files.

Table 2: Templates for input files

File Name	Input File	Location
RiverGeometry.xls	MAINFILE	River Geometry > Channel Map (Blocks F1 to F9)
RiverHydraulics.xls	FLOWFILE	Leopold- Maddock Coefficients (block G1)
BoundaryQuality.xls	FLOWFILE	Boundary Inflow Water Quality Distribution (Block K7)
WWTP_Qual.xls	STPFLOW	Point Source Water Quality (Block L7)
BoundaryFlows.xls	BASINFLOW	All (creates the input file)
WWTP_Flows.xls	STP_FLOW_FILE	All (creates the input file)
WaterTemp.xls	METDATA	All (creates the input file)

You can find an electronic copy of these templates in your GRSM download package, under the **Templates** directory. You will find additional guidance on how to use each template in the sections that follow. These instructions have been consolidated in **Appendix C: Using the Input File Templates**. For quick reference, each template also includes an Instructions tab that you can refer to while entering data.

4.4.3. MAINFILE

MAINFILE includes information regarding the basic program setup, river geometry, and some ecological parameters.

4.4.3.1. Template: RiverGeometry.xls

You can use the **RiverGeometry.xls** template to enter data more easily in the **River Geometry > Channel Map** section (Blocks F1 to F9) of this input file. To use this template, follow the steps described below.

1. Do not alter rows 1 and 2.
2. In column A, starting on row 3 with **Reach 1**, enter one row for each reach.
3. Enter the river geometry data for Blocks F1 to F9:
    - Column B: Define the upstream reach number.
    - Column C: Define the upstream percentage of flow from the previous reach to the current reach.
    - Column D: Define the reach number of the secondary upstream channel.
    - Column E: Define the percentage of flow from the secondary upstream channel to the current reach.
    - Column F: Define the current reach number.
    - Column G: Define the percentage of flow from the current reach to the next downstream reach.
    - Column H: Define the reach number of the secondary downstream channel.
    - Column I: Define the percentage of flow from the current reach to the secondary downstream reach.
    - Column J: Define the boundary number (consecutive, starting at 1).
    - Column K: Define the percentage of flow to the current reach from the boundary.
    - Column L: Define the local diffuse inflow (LDI) number (consecutive, starting at 1).
    - Column M: Define the percentage of flow to the current reach from the LDI.
    - Column N: Define the point source number (consecutive, starting at 1).
    - Column O: Define the percentage of flow to the current reach from the point source.
    - Column P: Define the withdrawal number (consecutive, starting at 1).
    - Column Q: Define the percentage of flow taken from the current reach.
    - Column R: Define the urban stormwater number (consecutive, starting at 1).
    - Column S: Define the percentage of flow to the current reach from the urban stormwater.
4. Ensure the **Geometry** worksheet is selected then click **Save As**.
5. From the **Save as type:** drop-down menu, select **Formatted Text (Space delimited) (*.prn)**.
6. Open the PRN file with your preferred text editor.
7. Select and copy (CTRL+C) the rows below CHANNEL MAP.

8. Paste (CTRL+V) the data in Blocks F1 to F9 of the MAINFILE input file.

4.4.3.2. File Description

Basics

Line 1		Simulation Setup

```
1 BASICS
2                        1   4 12152   2  15  60  60   6   1  10  38   2   8   1   0   0   0
3 -5331
4 PRINT SWITCHES         0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
5 INPUT DATA SWITCHES    0   0   1   0   0   0   0   1   0   0   0   0   0   0   0   0   1
6 GEOMETRY
```

FORMAT: FREE

Most Blocks of input data are preceded by a dummy line with the name of the section or headings. The dummy lines serve as error checks. When GRSM is reading the input files, it is looking for specific text to occur on specific lines of the input file. If the model does not find the correct text, it will produce an error message that indicates what text was expected and what text was actually encountered. This is a troubleshooting feature that can be useful for determining if the input files are correctly set up.

ERROR CHECK: BASICS

Line 2	Block A1 and A2	Simulation Setup

```
1 BASICS
2                        1   4 12152   2  15  60  60   6   1  10  38   2   8   1   0   0   0
3 -5331
4 PRINT SWITCHES         0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
5 INPUT DATA SWITCHES    0   0   1   0   0   0   0   1   0   0   0   0   0   0   0   0   1
6 GEOMETRY
```

FORMAT: 20X, 18I3

This sub-block defines the **basic conditions of the run and the basic characteristics of the system to be simulated**. Modify the first 14 parameters to describe the conditions of your simulation. Modify the last four parameters to facilitate calibration and specify the output desired from the ecological subroutine.

Reading left to right, the 18 parameters required in this sub-block are as follows:

NSEAS: The number of years in the simulation run. This ranges from a minimum of 1 to a maximum of 25. In the example above, the number of years in the simulation run is **1**.

NMTH: The number of months in each year to be simulated. This ranges from a minimum of 1 to a maximum of 12. In the example above, the number of months in the simulation is **4**.

N: The number of time steps in each day. At present, the GRSM is set up for **12** time steps per day as one time step spans 2 hours.

NSYD: The Julian day number of the first day of simulation (January 1st = 1, December 31 = 365). Care must be taken so that this value falls on the desired day, as the GRSM utilizes the input number of days in each month to define the Julian day range for each month. Leap years are not accounted for. In the example above, the Julian day number of the first day of simulation is June 1st, or **152**.

NWD: The day of the week on which simulation starts (Monday = 1, Sunday = 7). This value is used to start the model on sequence within the week and to synchronize the calculations within week flow variations. In the example above, the day of the week on which the simulation starts is Tuesday, or **2**.

NIF: The number of boundary location flows. This value should be the number of tributary boundary inflows plus one; the extra boundary location flow represents the total basin local diffuse inflow. In the above example, the number of boundary location flows is **15**.

NRCH: The number of reaches in the system. The model is presently limited to a maximum of 100 reaches. In the above example, the number of reaches in the system is **60**.

NJPT: The number of junction points in the system (equal to the number of downstream node points). In the above example, the number of junction points in the system is **60**.

NQP: The number of water quality parameters to be modelled (maximum of 10). At present, the GRSM is setup to model six parameters: DO, ultimate BOD, NOD, NIT, SS, and TP. The model also estimates un-ionized ammonia and is capable of simulating stream temperature when input data switch 7 is set to 0 (see below); however, these two parameters are not counted in the number to be simulated. In the above example, the number of water quality parameters to be modeled is **6**.

NSSEAS: The number of the year in which the simulation is to start. This value is usually 1; however, the selection of any other number allows for the simulation of the selected year out of a multi-year data set. In the above example, the number of years in which the simulation is to start is **1**.

NTF: The number of point source inputs (maximum of 30 can be input). In the above example, the number of point source inputs is **10**.

NDF (=NJPT-NIF+1): The number of local diffuse inflows. This is less than or equal to the number of junction points minus the number of boundary location flows. In the above example, the number of local diffuse inflows is **38**.

NWF: The number of withdrawal flows. A withdrawal is an abstraction of water from the system which results in a net loss of flow from the river, e.g., for municipal water supply, crop irrigation, etc.. In the above example, the number of withdrawal flows is **2**.

NSTOFL: The number of urban stormwater inputs to the system. The model is currently set for a maximum of 30 urban stormwater inputs. In the above example, the number of urban stormwater inputs to the system is **8**.

ICH: A switch for intermediate test prints from the ecological subroutine. This switch is used primarily during calibration and results in the printing of the results after each time step. A value of 1 = ON and 0 = OFF. In the above example, the switch for intermediate test prints from the ecological subroutine is on, or **1**.

LINECO: The number of lines to be printed if the switch is turned on. A maximum of 999 lines of print is allowed. In the above example, the number of lines to be printed if the switch is turned on is **0**.

IBEG: A switch to specify whether head or end of reach data are required as output if the switch is turned on. A value of 0 = head of the reach and 1 = end of the reach. In the above example, the switch to specify whether head or end of reach data are required is off, or **0**.

IBIOM: A switch to specify whether the user desires to have the final daily results from the ecological subroutine printed. A value of 1 = print results and 0 = no print. If this switch is turned on, the user must specify an output data set for unit 25. In the above example, the switch to specify whether the user desires to have the final daily results from the ecological subroutine printed is off, or **0**.

ERROR CHECK: BASICS

Execution

Line 3	Block –	

```
1 BASICS
2                                  1  4 12152  2 15  60  60   6   1 10  38   2   8   1   0   0   0
3 -5331
4 PRINT SWITCHES                   0  0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
5 INPUT DATA SWITCHES              0  0   1   0   0   0   0   1   0   0   0   0   0   0   0   0   1
6 GEOMETRY
```

FORMAT: I6

Line 3 consists of a random number seed, a large negative integer.

ERROR CHECK: N/A

Line 4	Block A3	Intermediate Printing

```
1 BASICS
2                                  1  4 12152  2 15  60  60   6   1 10  38   2   8   1   0   0   0
3 -5331
4 PRINT SWITCHES                   0  0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
5 INPUT DATA SWITCHES              0  0   1   0   0   0   0   1   0   0   0   0   0   0   0   0   1
6 GEOMETRY
```

FORMAT: 20X, 17I3

This line is used for calibration and can also be used to check the intermediate results from any or all of the 17 subroutines in GRSM. One parameter must be specified.

Each position acts as a switch for printing intermediate results from any of the 17 subroutines. A total of 17 values must be input; 1 = print, 0 = no print. This switch is usually left on for the position 1 so that the model echoes the control file set.

ERROR CHECK: N/A

Line 5	Block A4	Internal/External Switches

```
1 BASICS
2                      1  4 12152  2 15 60 60  6  1 10 38  2  8  1  0  0  0
3 -5331
4 PRINT SWITCHES       0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
5 INPUT DATA SWITCHES  0  0  1  0  0  0  0  1  0  0  0  0  0  0  0  0  1
6 GEOMETRY
```

FORMAT: 20X, 17I3

This line is used to specify the source of input data. The user specifies whether data are to be read in from an external system file or whether data are to be calculated internally from parameters specified in the control file set. There must be 17 values entered.

A value of 0 indicates that data are to be calculated internally. A value of 1 indicates that data are to be read from an external data file specified in FILENAME.DAT. At present, the option is effective for positions 3, 4, 8, 9, 11, 12, 13 and 17 corresponding to the point source flow and quality, local diffuse inflow quantity and quality, solar radiation as well as stream temperature, and the stormwater input quality and quantity. The options available to the user will be explained at the appropriate sections in the manual.

ERROR CHECK: N/A

River Geometry

Line 7

```
 6 GEOMETRY
 7 CHANNEL MAP          F1      F2      F3      F4      F5      F6      F7      F8      F9
 8 Reach  1          0   0   0   0  1100   0   0  1100   0   0   0   0   0   0   0   0
 9 Reach  2       1100   0   0  2100   0   0   0   0   0   0  1100   0   0  1100
10 Reach  3       2100   0   0  3100   0   0   0   0   0   0   0   0   0   0   0   0
11 Reach  4       3100   0   0  4100   0   0  2100  1100  2100   0   0  2100
12 Reach  5       4100   0   0  5100   0   0   0   0   0   0   0   0   0   0   0   0
13 Reach  6       5100   0   0  6100   0   0  3100   0   0   0   0   0   0   0   0
```

FORMAT: FREE

This line lists the nine nodes (the first position corresponds to node zero at the head of Reach 1).

ERROR CHECK: GEOMETRY

Lines 8 – 67	Block F1 – F9	River Geometry

```
 6 GEOMETRY
 7 CHANNEL MAP          F1      F2      F3      F4      F5      F6      F7      F8      F9
 8 Reach  1          0   0   0   0  1100   0   0  1100   0   0   0   0   0   0   0   0
 9 Reach  2       1100   0   0  2100   0   0   0   0   0   0  1100   0   0  1100
10 Reach  3       2100   0   0  3100   0   0   0   0   0   0   0   0   0   0   0   0
11 Reach  4       3100   0   0  4100   0   0  2100  1100  2100   0   0  2100
12 Reach  5       4100   0   0  5100   0   0   0   0   0   0   0   0   0   0   0   0
13 Reach  6       5100   0   0  6100   0   0  3100   0   0   0   0   0   0   0   0
```

FORMAT: 20X, 18I3

This block defines the basic geometry of the river system which is being modeled. This involves the description of the channel routing and includes a provision for splitting the main channel flow around islands, etc. This block is divided into eleven sub-blocks corresponding to channel routing and to locations of boundary inflows, point source inflows, local diffuse inflows, urban stormwater inputs, and withdrawal flows.

The GEOMETRY block is setup in 18I3 format with each of the reaches being allocated nine nodes (the first position corresponds to node zero at the head of Reach 1). All values entered in this block are three digit integer numbers. The first number in each sub-block is an identifier for either the node or the inflow (whether point, local diffuse, boundary, etc.). The second number in each sub-block represents the percentage of the flow which is routed to or from the node.

The river geometry is very important as it maintains flow continuity in the model. When creating or modifying the following sub-blocks, it may be necessary to first sketch a diagram of the river system and label the reaches and node numbers. This helps to prevent any errors in reach and node numbering, especially where two or more branches of the river exist and later join.

ERROR CHECK: N/A

	BLOCK F1	Main Upstream Channels

```
GEOMETRY
CHANNEL MAP             F1    F2     F3    F4     F5     F6     F7    F8     F9
Reach  1               0  0  0  0  1100  0  0  1100  0  0  0  0  0  0  0  0
Reach  2               1100  0  0  2100  0  0  0  0  0  0  1100  0  0  1100
Reach  3               2100  0  0  3100  0  0  0  0  0  0  0  0  0  0  0  0
Reach  4               3100  0  0  4100  0  0  2100  1100  2100  0  0  2100
Reach  5               4100  0  0  5100  0  0  0  0  0  0  0  0  0  0  0  0
Reach  6               5100  0  0  6100  0  0  3100  0  0  0  0  0  0  0  0
```

FORMAT: (3I3, I3)

The user must indicate the upstream node of the reach and the percentage of flow which is being routed from the downstream node of the upstream reach(es) to that upstream node. If there was only one upstream reach, then 100% of the flow should be applied to the node.

If the upstream node of the reach is at the head of a channel system, then the upstream node is ‘null' and the two digit identifying number of the upstream node is 00. The percentage of flow should be indicated as 0% as the upstream flow will be represented by the boundary inflow.

ERROR CHECK: N/A

	Block F2	Secondary Upstream Channels

```
GEOMETRY
CHANNEL MAP             F1    F2     F3    F4     F5     F6     F7    F8     F9
Reach  1               0  0  0  0  1100  0  0  1100  0  0  0  0  0  0  0  0
Reach  2               1100  0  0  2100  0  0  0  0  0  0  1100  0  0  1100
Reach  3               2100  0  0  3100  0  0  0  0  0  0  0  0  0  0  0  0
Reach  4               3100  0  0  4100  0  0  2100  1100  2100  0  0  2100
Reach  5               4100  0  0  5100  0  0  0  0  0  0  0  0  0  0  0  0
Reach  6               5100  0  0  6100  0  0  3100  0  0  0  0  0  0  0  0
```

FORMAT: (I3, I3)

The user must identify the nodes that correspond to an additional flow from a second upstream reach. This allows for the incorporation of an island or a tributary into the modeled river geometry.

ERROR CHECK: N/A

Execution

	Block F3	Main Downstream Channels

```
GEOMETRY
CHANNEL MAP          F1     F2     F3    F4     F5     F6     F7     F8     F9
Reach  1           0   0   0   0  1100  0   0  1100   0   0   0   0   0   0   0   0
Reach  2           1100    0   0  2100  0   0   0   0   0   0  1100   0   0  1100
Reach  3           2100    0   0  3100  0   0   0   0   0   0   0   0   0   0   0   0
Reach  4           3100    0   0  4100  0   0  2100  1100   2100   0   0  2100
Reach  5           4100    0   0  5100  0   0   0   0   0   0   0   0   0   0   0   0
Reach  6           5100    0   0  6100  0   0  3100   0   0   0   0   0   0   0   0
```

FORMAT: (I3, I3)

The user must enter the downstream node number and the flow percentage that the reach flow is conveyed to. If there is not a flow distribution, 100% of the flow should be conveyed to the reach's downstream node.

ERROR CHECK: N/A

	Block F4	Secondary Downstream Channels

```
GEOMETRY
CHANNEL MAP          F1     F2     F3    F4     F5     F6     F7     F8     F9
Reach  1           0   0   0   0  1100  0   0  1100   0   0   0   0   0   0   0   0
Reach  2           1100    0   0  2100  0   0   0   0   0   0  1100   0   0  1100
Reach  3           2100    0   0  3100  0   0   0   0   0   0   0   0   0   0   0   0
Reach  4           3100    0   0  4100  0   0  2100  1100   2100   0   0  2100
Reach  5           4100    0   0  5100  0   0   0   0   0   0   0   0   0   0   0   0
Reach  6           5100    0   0  6100  0   0  3100   0   0   0   0   0   0   0   0
```

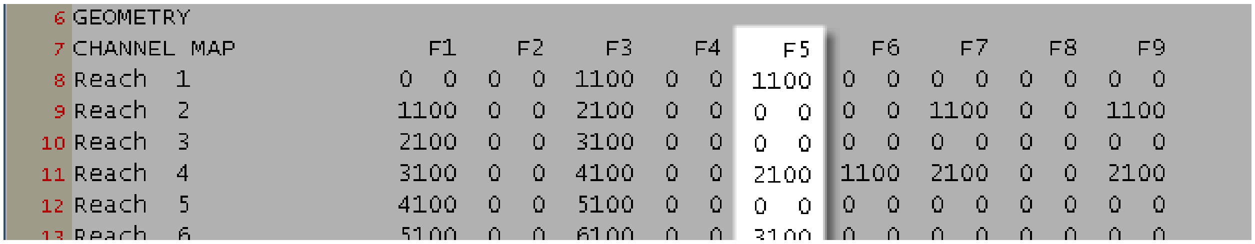
FORMAT: (I3, I3)

This sub-block defines the node locations and flow percentages which are routed downstream through a secondary channel. This allows for the incorporation of an island or a flow distribution into the river system.

ERROR CHECK: N/A

Execution

	Block F5	Boundary Location Flows



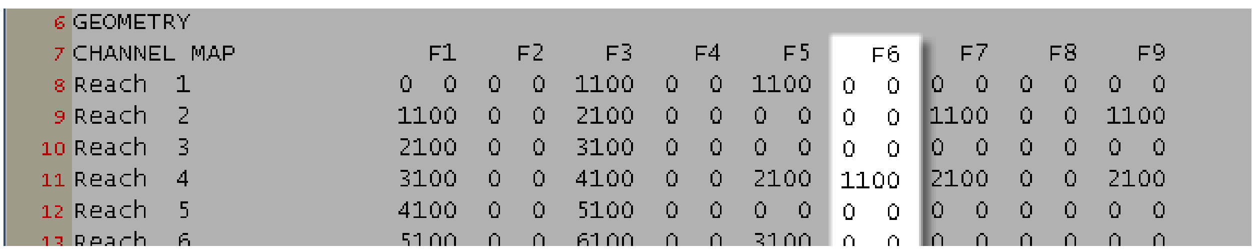
```
 6 GEOMETRY
 7 CHANNEL MAP        F1      F2      F3      F4      F5      F6      F7      F8      F9
 8 Reach  1          0   0   0   0  1100  0   0  1100  0   0   0   0   0   0   0   0
 9 Reach  2        1100  0   0   0  2100  0   0   0   0   0   0  1100  0   0  1100
10 Reach  3        2100  0   0   0  3100  0   0   0   0   0   0   0   0   0   0   0   0
11 Reach  4        3100  0   0   0  4100  0   0  2100 1100 2100  0   0  2100
12 Reach  5        4100  0   0   0  5100  0   0   0   0   0   0   0   0   0   0   0   0
13 Reach  6        5100  0   0   0  6100  0   0  3100  0   0   0   0   0   0   0   0
```

FORMAT: (I3, I3)

The first integer describes the boundary location flow number and the second number is the flow percentages while the position describes the reach that the boundary location flow is applied to. The model applies the boundary location flow to the upstream node of that reach.

ERROR CHECK: N/A

	Block F6	Local Diffuse Inflows



```
 6 GEOMETRY
 7 CHANNEL MAP        F1      F2      F3      F4      F5      F6      F7      F8      F9
 8 Reach  1          0   0   0   0  1100  0   0  1100  0   0   0   0   0   0   0   0
 9 Reach  2        1100  0   0   0  2100  0   0   0   0   0   0  1100  0   0  1100
10 Reach  3        2100  0   0   0  3100  0   0   0   0   0   0   0   0   0   0   0   0
11 Reach  4        3100  0   0   0  4100  0   0  2100 1100 2100  0   0  2100
12 Reach  5        4100  0   0   0  5100  0   0   0   0   0   0   0   0   0   0   0   0
13 Reach  6        5100  0   0   0  6100  0   0  3100  0   0   0   0   0   0   0   0
```

FORMAT: (I3, I3)

This sub-block defines the location of local diffuse inflows and the flow percentage applied to that reach. The first integer is the number of the local diffuse inflow. The second number is the percentage of the flow directed to the current reach and the position within the matrix identifies the reach that the diffuse inflow is applied to. One hundred percent of the flow enters the upstream node of the reach.

ERROR CHECK: N/A

Execution

	Block F7	Point Source (WWTP) Inflows

```
 6 GEOMETRY
 7 CHANNEL MAP        F1    F2    F3    F4    F5    F6    F7    F8    F9
 8 Reach  1          0  0  0  0 1100  0  0 1100  0  0  0  0  0  0  0  0
 9 Reach  2         1100  0  0 2100  0  0  0  0  0  0 1100  0  0 1100
10 Reach  3         2100  0  0 3100  0  0  0  0  0  0  0  0  0  0  0  0
11 Reach  4         3100  0  0 4100  0  0 2100 1100 2100  0  0 2100
12 Reach  5         4100  0  0 5100  0  0  0  0  0  0  0  0  0  0  0  0
13 Reach  6         5100  0  0 6100  0  0 3100  0  0  0  0  0  0  0  0
```

FORMAT: (I3, I3)

This sub-block defines the locations and flow percentages of the point source inflows. Point source inflows are applied to the upstream node of a reach. The first integer is the number of the point source inflow. The second number is the percentage of the flow directed to the current reach and the position within the matrix identifies the reach that the point source flow is applied to.

ERROR CHECK: N/A

	Block F8	Withdrawal Flow Locations

```
 6 GEOMETRY
 7 CHANNEL MAP        F1    F2    F3    F4    F5    F6    F7    F8    F9
 8 Reach  1          0  0  0  0 1100  0  0 1100  0  0  0  0  0  0  0  0
 9 Reach  2         1100  0  0 2100  0  0  0  0  0  0 1100  0  0 1100
10 Reach  3         2100  0  0 3100  0  0  0  0  0  0  0  0  0  0  0  0
11 Reach  4         3100  0  0 4100  0  0 2100 1100 2100  0  0 2100
12 Reach  5         4100  0  0 5100  0  0  0  0  0  0  0  0  0  0  0  0
13 Reach  6         5100  0  0 6100  0  0 3100  0  0  0  0  0  0  0  0
```

FORMAT: (I3, I3)

This sub-block is used to define the locations of the withdrawal flow from the system. For this model, a withdrawal flow is defined as a permanent abstraction of water from the system for irrigation, municipal drinking water, etc. Withdrawal flows are applied at the upstream node of a reach. The first integer is the number of the withdrawal flow. The second number is the percentage of the flow withdrawn from the current reach and the position within the matrix identifies the reach that the withdrawal flow is applied to.

ERROR CHECK: N/A

Execution

	Block F9	Urban Stormwater Inputs

```
 6 GEOMETRY
 7 CHANNEL MAP            F1      F2      F3      F4      F5      F6      F7      F8      F9
 8 Reach  1            0    0    0    0 1100    0    0 1100    0    0    0    0    0    0    0    0
 9 Reach  2         1100    0    0 2100    0    0    0    0    0    0 1100    0    0    0 1100
10 Reach  3         2100    0    0 3100    0    0    0    0    0    0    0    0    0    0    0    0
11 Reach  4         3100    0    0 4100    0    0 2100 1100 2100    0    0 2100
12 Reach  5         4100    0    0 5100    0    0    0    0    0    0    0    0    0    0    0    0
13 Reach  6         5100    0    0 6100    0    0 3100    0    0    0    0    0    0    0    0    0
```

FORMAT: (I3, I3)

The input data describes the location of the urban stormwater inflows and the percentage. Urban flows are added to the upstream node of the reach. The first integer is the number of the urban inflow. The second number is the percentage of the flow directed to the current reach and the position within the matrix identifies the reach that the urban inflow is applied to.

ERROR CHECK: N/A

Lines 69-70	Block F10	Withdrawal Rates

```
67 Reach 60            59100    0    0 60100    0    0 14100    0    0    0    0    0    0    0    0
68 WITHDRAWAL RATES
69                        0.442     0.442     0.442     0.442     0.442     0.442     0.442
70                        0.566     0.566     0.566     0.566     0.566     0.566     0.566
71 MUSKINGUM COEFFICIENTS
```

FORMAT: 20X, 3F10.3

Data in this sub-block define withdrawal flows in cubic metres per second (cms). Values input are the mean monthly withdrawals. Twelve values, one per month for each withdrawal flow, must be entered. In the example above, two withdrawal flows were specified.

ERROR CHECK: WITHDRAWAL RATES

Lines 72-131	Block F11	Muskingum Coefficients

```
69                        15.6     15.6     15.6     15.6     15.
70                        20.0     20.0     20.0     20.0     20.
71 MUSKINGUM COEFFICIENTS
72 REACH   1                0.00     1.00     0.00
73 REACH   2                0.00     1.00     0.00
74 REACH   3                0.00     1.00     0.00
75 REACH   4                0.00     1.00     0.00
76 REACH   5                0.00     1.00     0.00
77 REACH   6                0.00     1.00     0.00
78 REACH   7                0.00     1.00     0.00
```

FORMAT: 20X, 3F10.3

The GRSM model employs the Muskingum method of flow routing. This sub-block requires three Muskingum flow routing coefficients for each reach. The default values shown above assume no transient storage of water within a particular reach (i.e., sum of inflow to a reach during one timestep = outflow during the same timestep).

ERROR CHECK: MUSKINGUM COEFFICIENTS

Lines 133-192	Block P1	Reach Length

```
132 REACH LENGTHS                  IN METRES
133 Reach   1          5752.744
134 Reach   2           2386.28
135 Reach   3          3098.476
136 Reach   4          3170.427
137 Reach   5          2184.146
138 Reach   6            776.22
139 Reach   7          7744.512
```

FORMAT: 20X, F10.3

The user must enter the lengths of each reach in metres.

ERROR CHECK: REACH LENGTHS

Line 194-254	Block J6	Base Depths

```
190 Reach 58            21680.0
191 Reach 59            16514.0
192 Reach 60            12549.0
193 BASE DEPTHS 12 MONTHS  BY REACH
194                       J         F         M         A         M         J         J         A         S         O         N         D
195 REACH  1           2.00      2.00      2.00      2.00      2.00      2.00      2.00      2.00      2.00      2.00      2.00      2.00
196 REACH  2           2.00      2.00      2.00      2.00      2.00      2.00      2.00      2.00      2.00      2.00      2.00      2.00
197 REACH  3           2.00      2.00      2.00      2.00      2.00      2.00      2.00      2.00      2.00      2.00      2.00      2.00
198 REACH  4           2.00      2.00      2.00      2.00      2.00      2.00      2.00      2.00      2.00      2.00      2.00      2.00
199 REACH  5           2.00      2.00      2.00      2.00      2.00      2.00      2.00      2.00      2.00      2.00      2.00      2.00
200 REACH  6           2.00      2.00      2.00      2.00      2.00      2.00      2.00      2.00      2.00      2.00      2.00      2.00
201 REACH  7           2.00      2.00      2.00      2.00      2.00      2.00      2.00      2.00      2.00      2.00      2.00      2.00
```

FORMAT: 20X, 12F10.3

The base depths of each reach in feet for each month are required. This parameter is used in the ‘volumetric rate constant’ (AGSLU, AGRES, AGPH) calculations in FLO.FOR; the last two constants are used when ECOL is turned ‘off’. Presently, the ‘base’ data for AGRES and AGPH are not read in because the ECOL subroutine is being used.

ERROR CHECK: BASE DEPTHS

Ecological Parameters

This section of control data is used by the ecological subroutine in GRSM and is divided into 11 sub-blocks. Inputs to these sub-blocks define the characteristics of the biomass species which are to be simulated. Required input to the sub-blocks is provided below; however, for more detailed definitions of the input parameter, refer to the GRSM Technical Guidance Document, available under separate cover.

Line 257	Q1, Q2, Q3	Ecological Rate Constants

```
255 ECOL_CONSTANTS
256       CGMEW      PPMEW      EPMEW     KMLC      KMLP      KMLE       PASSC
257       0.019      0.020      0.020     0.200     0.200     0.200      0.002
258       PASSP      PASSE      ANASS     O2ASS     CGR20     PPR20      EPR20
259       0.002      0.002      0.02      1.65      0.003     0.003      0.003
260       TC         TP         TE        REQFAC    POTFAC    EPIFAC
261       1.1        1.1        1.1       5.4       9.60      5.4
```

FORMAT: 7F10.3

The input for each of the seven parameters are required:

- **CGMEW:** Specific growth rate of *Cladophora glomerata* (g/g hr)
- **PPMEW:** Specific growth rate of *Potamogeton pectinatus* (g/g hr)
- **EPMEW:** Specific growth rate of milfoil (g/g hr)
- **KMLC:** Light model constant for Cladophora (Langleys/min)
- **KMLP:** Light model constant for Potamogeton (Langleys/min)
- **KMLE:** Light model constant for milfoil (Langleys/min)
- **PASSC:** Assimilation ratio of phosphorus for Cladophora (g P/g biomass)

ERROR CHECK: ECOL_CON

Line 259	Block Q21	Ecological Rate Constants

```
255 ECOL_CONSTANTS
256       CGMEW      PPMEW      EPMEW     KMLC      KMLP      KMLE       PASSC
257       0.019      0.020      0.020     0.200     0.200     0.200      0.002
258       PASSP      PASSE      ANASS     O2ASS     CGR20     PPR20      EPR20
259       0.002      0.002      0.02      1.65      0.003     0.003      0.003
260       TC         TP         TE        REQFAC    POTFAC    EPIFAC
261       1.1        1.1        1.1       5.4       9.60      5.4
```

FORMAT: 7F10.3

Seven parameters are required as input:

- **PASSP:** Assimilation ratio of phosphorus for Potamogeton (g P/g biomass)
- **PASSE:** Assimilation ratio of phosphorus for milfoil (g P/g biomass)
- **ANASS:** Universal nitrogen assimilation ratio (g N/g biomass)
- **O2ASS:** Universal oxygen assimilation ratio (g 0_2/g biomass)
  (This term is used for both photosynthetic oxygen production and respiratory oxygen uptake)
- **CGR20:** Unit respiration rate of Cladophora at 20°C (g 0_2/g-hr)
- **PPR20:** Unit respiration rate of Potamogeton at 20°C (g 0_2/g-hr)

- **EPR20:** Unit respiration rate of milfoil at 20°C (g 0_2/g-hr)

ERROR CHECK: N/A

Line 261	Q1, Q2, Q3	Ecological Rate Constants

```
255 ECOL_CONSTANTS
256       CGMEW     PPMEW     EPMEW    KMLC      KMLP      KMLE      PASSC
257       0.019     0.020     0.020     0.200     0.200     0.200    0.002
258       PASSP     PASSE     ANASS     O2ASS     CGR20     PPR20    EPR20
259       0.002     0.002     0.02      1.65      0.003     0.003    0.003
260       TC        TP        TE       REQFAC     POTFAC    EPIFAC
261       1.1       1.1       1.1       5.4       9.60      5.4
```

FORMAT: 6F10.3

Six parameters are required as input:

TC: Temperature model constant for Cladophora (unitless)

TP: Temperature model constant for Potamogeton (unitless)

TE: Temperature model constant for milfoil (unitless)

REQFAC: Nutrient utilization efficiency factor for Cladophora (unitless)

POTFAC: Nutrient utilization efficiency factor for Potamogeton (unitless)

EPIFAC: Nutrient utilization efficiency factor for milfoil (unitless)

ERROR CHECK: N/A

Line 263	Block Q21	CLAD Temperature Growth Relationships

```
260      TC        TP        TE       REQFAC    POTFAC    EPIFAC
261      1.1       1.1       1.1       5.4      9.60      5.4
262 CLAD TEMPERATURE GROWTH RELATIONSHIP COEFFICIENTS
263      4.0       7.0      23.0      28.0      0.100     0.98      0.98      0.100
264 POTE TEMPERATURE GROWTH RELATIONSHIP COEFFICIENTS
265     10.0      24.0      31.0      37.0      0.100     0.98      0.98      0.100
```

FORMAT: 8F10.3

An equation links the water temperature to the growth of CLAD. The curve has a minimum temperature (TEMPMINC), two optimal growth temperatures (low, TEMPOPT2C, and high, TEMPOPT3C), a maximum temperature (TEMPMAXC), and four shape factors (K1C, K2C, K3C, and K4C).

ERROR CHECK: CLAD TEMPERA

Line 265	Block Q22	POT Temperature Growth Relationships

```
262 CLAD TEMPERATURE GROWTH RELATIONSHIP COEFFICIENTS
263      4.0       7.0      23.0      28.0     0.100      0.98      0.98     0.100
264 POTE TEMPERATURE GROWTH RELATIONSHIP COEFFICIENTS
265     10.0      24.0      31.0      37.0     0.100      0.98      0.98     0.100
266 MILFOIL TEMPERATURE GROWTH RELATIONSHIP COEFFICIENTS
267     10.0      30.0      35.0      54.0     0.100      0.98      0.98     0.100
```

FORMAT: 8F10.3

An equation links the water temperature to the growth of POT. The curve has a minimum temperature (TEMPMINP), two optimal growth temperatures (low, TEMPOPT2P, and high, TEMPOPT3P), a maximum temperature (TEMPMAXP), and four shape factors (K1P, K2P, K3P, and K4P).

ERROR CHECK: POTE TEMPERA

Line 267	Block Q22	MIL Temperature Growth Relationships

```
260       TC        TP        TE    REQFAC    POTFAC    EPIFAC
261      1.1       1.1       1.1       5.4      9.60       5.4
262 CLAD TEMPERATURE GROWTH RELATIONSHIP COEFFICIENTS
263      4.0       7.0      23.0      28.0     0.100      0.98      0.98     0.100
264 POTE TEMPERATURE GROWTH RELATIONSHIP COEFFICIENTS
265     10.0      24.0      31.0      37.0     0.100      0.98      0.98     0.100
266 MILFOIL TEMPERATURE GROWTH RELATIONSHIP COEFFICIENTS
267     10.0      30.0      35.0      54.0     0.100      0.98      0.98     0.100
```

FORMAT: 8F10.3

An equation links the water temperature to the growth of milfoil. The curve has a minimum temperature (TEMPMIN), two optimal growth temperatures (low, TEMPOPT2M, and high, TEMPOPT3M), a maximum temperature (TEMPMAXM), and four shape factors (K1M, K2M, K3M, and K4M).

ERROR CHECK: MILFOIL TEMP

Line 269	Block Q24	Michaelis-Menton Factors

```
266 MILFOIL TEMPERATURE GROWTH RELATIONSHIP COEFFICIENTS
267      10.0      30.0      35.0      54.0     0.100      0.98      0.98     0.100
268 MICHAELIS MENTEN KINETICS
269       0.20      83.0      0.07      0.03       8.0       8.0
270 RADIATION FACTOR
271      0.027
```

FORMAT: 6F10.3

The nutrient factors for Cladophora, Potamogeton, and milfoil are entered on one line. The factors are given in the following order:

ROWPMAX: maximum P uptake rate for Cladophora

KMPCLAD: half saturation constant for external P for Cladophora

KQPCLAD: half saturation constant for internal P for Cladophora

QNOT: minimum internal P concentration for Cladophora

KMPPOT: half saturation constant for external P for Potamogeton

KMPEPI: half saturation constant for external P for Milfoil

ERROR CHECK: MICHAELIS ME

Line 271	Block Q25	Radiation Factor

```
270 RADIATION FACTOR
271      0.027
272 WASHOFF FACTORS - CLAD, POT, MILFOIL
273     0.0005    0.0005    0.0005
```

FORMAT: F10.3

This factor was historically used to scale the radiation available for biomass in order to limit growth but is no longer used in favour of a more comprehensive approach to estimating plant-available light in the water column (see below).

ERROR CHECK: N/A

Execution

Line 273	Block Q26	Biomass Washoff Factors

```
272 WASHOFF FACTORS - CLAD, POT, MILFOIL
273      0.0005     0.0005      0.0005
274 WASHOFF TEMPERATURES - CLAD, POT, MILFOIL
275      22.0       15.0       15.5
```

FORMAT: 3F10.3

Individual washoff factors for each species must be entered. The value represents a percentage of biomass that is sloughed off at each time step. Typical values are 0.0005. You may use these factors as a calibration parameter, to adjust the amount of aquatic plant biomass that is lost in each timestep due to senescence, grazing by invertebrates or waterfowl, etc.

ERROR CHECK: WASHOFF FACT

Line 275	Block Q27	Biomass Washoff Temperatures

```
274 WASHOFF TEMPERATURES - CLAD, POT, MILFOIL
275      22.0       15.0       15.5
276 KE RATE AND KE_CONSTANT AND PLANT_DEPTH
277       0.093      1.111      0.90       1.000
```

FORMAT:3F10.3

Individual washoff temperatures for each species must be entered. The value is the critical temperature used to trigger accelerated washoff at rates different from the above values. Cladophora washes off at high temperatures while Potemogeton washes off at low temperatures. The milfoil temperature is not used in this version but future versions have the potential to use the value.

ERROR CHECK: WASHOFF TEMP

Line 277	Block Q28	Light Attenuation Factors

```
274 WASHOFF TEMPERATURES - CLAD, POT, MILFOIL
275      22.0       15.0       15.5
276 KE RATE AND KE_CONSTANT AND PLANT_DEPTH
277       0.093      1.111      0.90       1.000
278 AREA LATITUDE
279      43.0
```

FORMAT:4F10.3

You must enter four values that represent the attenuation of light in the water column due to suspended sediment and self-shading of aquatic biomass. These factors affect the rate of plant growth and photosynthesis. The first value entered is the slope of the exponential decay coefficient (KE_SLOPE, m^2/mg) and the second value (KE_CONSTANT, 1/m) is the constant in a linear regression of the exponential decay coefficient vs. suspended solids concentration. The third value is the plant depth cut-off (PLANT_DEPTH, feet). At depths less than the plant depth there is no light attenuation. Greater depths use the light attenuation function. The fourth value in this row determines which of the following methods is used to determine light attenuation in the water column:

1) PARD=WATI*EXP(-KE * (DEPTH - PLANT_DEPTH) – KW *(CLAD+POT+EPI)) 2) PARD=WATI*EXP(KE * (PLANT_DEPTH - DEPTH)) 3) PARD=WATI*EXP(-KE * DEPTH/2.) 4) PARD=WATI Where: **PARD** is the amount of radiation available to the aquatic plants **WATI** is the radiation available at the water surface **KE** = KE_SLOPE * TSS + KE_CONSTANT **DEPTH** is the depth of water in a particular reach at a particular timestep **PLANT_DEPTH** is the cut-off depth described above **KW** is a self-shading factor equal to 0.024 if Cladophora or Potamogeton are dominant or 0.0083 if milfoil is the dominant plant type
ERROR CHECK: KE RATE AND

Line 279	Block Q29	Area Latitude

```
278 AREA LATITUDE
279       43.0
280 STARTING MASS               CLAD        POT         MIL
```

FORMAT: F10.3
The approximate latitude in degrees for the watershed is required. It is used to calculate the angle of incident sunlight.
ERROR CHECK: AREA LATITUDLATITUD

Line 281-340	Block Q4, Q5, Q6	CLAD, POT, MIL Starting Mass

```
280 STARTING MASS               CLAD        POT         MIL
281 REACH   1                   36.3        10.0         5.0
282 REACH   2                   33.8        10.0         5.0
283 REACH   3                   32.9        10.0         5.0
```

FORMAT: 20X, 3F10.3
Specify the initial starting biomass (g/m² dry weight) of Cladophora, Potamogeton, and milfoil for each reach. One line per reach.
ERROR CHECK: STARTING MAS

Execution

Line 342-401	Block Q7	Initial Phosphorus in Plant Tissue

```
341 PHOSPHORUS IN PLANT TISSUES BY REACH
342 REACH  1                  0.002
343 REACH  2                  0.002
344 REACH  3                  0.002
345 REACH  4                  0.002
346 REACH  5                  0.002
347 REACH  6                  0.002
```

FORMAT: 20X, F10.3

Enter the initial concentration of phosphorus in plant tissue (g P/g) for each reach. It is assumed that initial plant tissue concentrations are the same for the three plant species. One line per reach.

ERROR CHECK: PHOSPHORUS I

Line 403-462	Block Q8	Initial Organic Nitrogen in Water

```
402 ORGANIC NITROGEN STARTING MASS     1 EACH MONTH PER REACH
403 REACH  1 Shand       0.76   0.76   0.64   0.64   0.64   0.70   0.70   0.70   0.70   0.74   0.74   0.76
404 REACH  2             0.76   0.76   0.66   0.66   0.66   0.70   0.70   0.70   0.70   0.74   0.74   0.76
405 REACH  3             0.77   0.77   0.67   0.67   0.67   0.71   0.71   0.71   0.71   0.74   0.74   0.77
406 REACH  4             0.77   0.77   0.69   0.69   0.69   0.71   0.71   0.71   0.71   0.74   0.74   0.77
407 REACH  5             0.77   0.77   0.70   0.70   0.70   0.71   0.71   0.71   0.71   0.75   0.75   0.77
```

FORMAT: 20X, 12F10.3

Enter the initial value of organic nitrogen (ORGN) in the water in mg/L. This value is used to estimate the concentration of total ammonia nitrogen (TAN), assuming TAN = NOD/4.57 – ORGN. Un-ionized ammonia (UIA) is estimated based on TAN, pH and temperature. Enter 12 values for each reach, one per month. Each reach gets one line.

ERROR CHECK: ORGANIC NITR

Line 463-523	Block R1	Average Monthly pH

```
463 PH_MONTH             12 PER MONTH BY REACH
464 REACH  1 Shand       8.42   8.26   8.33   8.46   8.41   8.11   8.07   8.04   8.05   7.50   7.54   8.36
465 REACH  2             8.42   8.25   8.30   8.44   8.40   8.12   8.08   8.06   8.09   7.57   7.60   8.35
466 REACH  3             8.41   8.24   8.28   8.42   8.38   8.13   8.10   8.09   8.13   7.64   7.66   8.34
467 REACH  4             8.41   8.23   8.26   8.40   8.36   8.14   8.11   8.11   8.17   7.72   7.72   8.32
468 REACH  5             8.40   8.21   8.23   8.38   8.35   8.15   8.13   8.14   8.21   7.79   7.78   8.31
469 REACH  6             8.39   8.20   8.21   8.36   8.33   8.15   8.14   8.16   8.25   7.86   7.84   8.30
```

FORMAT: 20X, 12F0.3

These values represent the average monthly pH in each reach based on monitoring data (where available). The GRSM uses data in this sub-block to determine the un-ionized ammonia fraction during its water quality calculations. Enter 12 values (average pH) for each reach; one reach per line.

ERROR CHECK: PH_MONTH

Line 525-584	Block S1	Average Daily pH Variation

```
524 PH_DAILY                JAN      FEB      MAR      APR      MAY      JUN      JUL      AUG      SEPT     OCT      NOV      DEC
525 REACH  1 Shand          0.11     0.10     0.11     0.22     0.28     0.19     0.20     0.44     0.26     0.67     0.19     0.11
526 REACH  2               0.11     0.11     0.12     0.22     0.29     0.21     0.22     0.45     0.29     0.65     0.20     0.11
527 REACH  3               0.10     0.12     0.13     0.22     0.30     0.24     0.24     0.45     0.32     0.64     0.21     0.12
528 REACH  4               0.10     0.13     0.14     0.22     0.31     0.26     0.26     0.46     0.34     0.62     0.22     0.12
529 REACH  5               0.10     0.13     0.15     0.22     0.32     0.29     0.28     0.47     0.37     0.61     0.22     0.13
530 REACH  6               0.10     0.14     0.16     0.21     0.32     0.31     0.31     0.47     0.40     0.59     0.23     0.14
```

FORMAT: 20X, 12F10.3

This sub-block further defines the characteristics of the pH in the river system. Enter the average daily pH variation for each month for each reach. This value represents the difference between the maximum daily pH and minimum daily pH, i.e., the amplitude of the daily variation in pH. GRSM estimates pH for each timestep assuming the pH varies sinusoidally around the average value (see previous block) with the maximum occurring at timestep 9 (i.e., 6:00pm) and the minimum occurring at timestep 3 (i.e., 6:00 am). Enter 12 monthly values for each reach; one reach per line.

ERROR CHECK: PH_DAILY

Line 586-645	Block T1a	Cladophora Growth Inhibition

```
585 CLADOPHORA GROWTH INHIBITION 12 YEAR PER REACH
586 REACH  1               1.00     1.00     1.00     1.00     1.00     0.60     0.60     0.60     0.60     1.00     1.00     1.00
587 REACH  2               1.00     1.00     1.00     1.00     1.00     0.60     0.60     0.60     0.60     1.00     1.00     1.00     1.00
588 REACH  3               1.00     1.00     1.00     1.00     1.00     0.60     0.60     0.60     0.60     1.00     1.00     1.00     1.00
589 REACH  4               1.00     1.00     1.00     1.00     1.00     0.70     0.70     0.70     0.70     1.00     1.00     1.00
590 REACH  5               1.00     1.00     1.00     1.00     1.00     0.75     0.75     0.75     0.75     1.00     1.00     1.00
591 REACH  6               1.00     1.00     1.00     1.00     1.00     0.85     0.85     0.85     0.85     1.00     1.00     1.00
```

FORMAT:20X,12F10.3

Enter a CLAD (Cladophora) growth inhibition factor for each month and each reach (12 values must be entered). The growth inhibition factor allows the user to account for effects that are not explicitly modeled and may inhibit or prohibit aquatic plant growth, e.g., phytotoxic substances, grazing pressure from invertebrates or waterfoul, lack of suitable habitat, etc. in reaches which otherwise would exhibit luxuriant plant growth. If no inhibition is required, the values should be set to 1.0. This parameter is used as a calibration parameter and is adjusted typically between 0.8 and 1.2.

ERROR CHECK: CLADOPHORA GROWTH IN

Line 647-706	Block T1b	Potemogetan Growth Inhibition

```
645 REACH 60               1.00     1.00     1.00     1.00     1.00     1.00     1.00     1.00     1.00     1.00     1.00     1.00
646 POTEMOGETON GROWTH INHIBITION 12 YEAR PER REACH
647 REACH  1               1.00     1.00     1.00     1.00     1.00     1.00     1.00     1.00     1.00     1.00     1.00     1.00
648 REACH  2               1.00     1.00     1.00     1.00     1.00     1.00     1.00     1.00     1.00     1.00     1.00     1.00
649 REACH  3               1.00     1.00     1.00     1.00     1.00     1.00     1.00     1.00     1.00     1.00     1.00     1.00
```

FORMAT:20X, 12F10.3

Enter a POT (Potamogeton) growth inhibition factor for each month and each reach (12 values must be entered). The growth inhibition factor allows the user to account for effects that are not explicitly modeled and may inhibit or prohibit aquatic plant growth, e.g., phytotoxic substances, grazing pressure from invertebrates or waterfoul, lack of suitable habitat, etc. in reaches which otherwise would exhibit luxuriant plant growth. If no inhibition is required, the values should be set to 1.0. This parameter is used as a calibration parameter and is adjusted typically between 0.8 and 1.2.

ERROR CHECK: POTEMOGETON GROWTH I

Execution

Line 708-767	Block T1c	Milfoil Growth Inhibition

```
706 REACH 60              1.00      1.00      1.00      1.00      1.00      1.00      1.00      1.00      1.00      1.00      1.00      1.00
707 MILFOIL GROWTH INHIBITION 12 YEAR PER REACH
708 REACH  1              1.00      1.00      1.00      1.00      1.00      1.00      1.00      1.00      1.00      1.00      1.00      1.00
709 REACH  2              1.00      1.00      1.00      1.00      1.00      1.00      1.00      1.00      1.00      1.00      1.00      1.00
710 REACH  3              1.00      1.00      1.00      1.00      1.00      1.00      1.00      1.00      1.00      1.00      1.00      1.00
711 REACH  4              1.00      1.00      1.00      1.00      1.00      1.00      1.00      1.00      1.00      1.00      1.00      1.00
712 REACH  5              1.00      1.00      1.00      1.00      1.00      1.00      1.00      1.00      1.00      1.00      1.00      1.00
713 REACH  6              1.00      1.00      1.00      1.00      1.00      1.00      1.00      1.00      1.00      1.00      1.00      1.00
```

FORMAT: 20X, 12F10.3

Enter a MIL (Milfoil) growth inhibition factor for each month and each reach (12 values must be entered). The growth inhibition factor allows the user to account for effects that are not explicitly modeled and may inhibit or prohibit aquatic plant growth, e.g., phytotoxic substances, grazing pressure from invertebrates or waterfoul, lack of suitable habitat, etc. in reaches which otherwise would exhibit luxuriant plant growth. If no inhibition is required, the values should be set to 1.0. This parameter is used as a calibration parameter and is adjusted typically between 0.8 and 1.2.

ERROR CHECK: MILFOIL GROWH INHIB

4.4.4. RATEFILE

RATEFILE includes information defining the stream rate parameters, such as solar radiation, temperature and process rate factors.

4.4.4.1. File Description

Solar Radiation Parameters

GRSM is currently hard-coded to accept water temperature and solar radiation data from an external file (i.e., the METDATA file). The blocks with a grey background are not used by the model but **must** be included in the input file for the model to run properly.

Line 1	Block	Solar Radiation

```
1 SOLAR RADIATION
2 MEAN MONTHLY DAILY SOLAR RADIATION
3                              J         F         M         A         M         J         J
4                           200.      200.      200.      200.      701.      463.      546.
5 SUNLIGHT INTENSITY FACTOR
```

FORMAT: FREE
All blocks are preceded by a dummy line with the name of the section or headings. The dummy lines serve as error checks.
ERROR CHECK: SOLAR RA

Lines 3-4	Block H1	Mean Monthly Solar Radiation

```
1 SOLAR RADIATION
2 MEAN MONTHLY DAILY SOLAR RADIATION
3                              J         F         M         A         M         J         J
4                           200.      200.      200.      200.      701.      463.      546.
5 SUNLIGHT INTENSITY FACTOR
```

FORMAT: 20X, 12F10.3
This block defines the characteristics of the solar radiation used in the ecological subroutine. Enter the mean total daily solar radiation (Langleys) for each month (12 values in total). This block is not used in the current version of GRSM.
ERROR CHECK: MEAN MONTHLYMONTHLY

Line 6-7	Block H2	Sunlight Intensity Factor

```
5 SUNLIGHT INTENSITY FACTOR
6                          J          F          M          A          M          J          J
7                          1.         1.         1.         1.         1.         1.55       0.70
8 SOLAR PROB DS         No. OF ENTRIES PER LINE AND THEN THE ENTRIES
9  J                              11    200.       200.       200.       200.       200.       200.
```

FORMAT: 20X, 12F10.3

Enter a sunlight intensity factor coefficient for each month (12 values in total). This factor is used to account for the seasonal variation in sunlight intensity, i.e., the sunlight on a bright sunny day in summer is more intense than that on a comparable day in winter.

This block is not used in the current version of GRSM.

ERROR CHECK: SUNLIGHT INT

Line 9 – 20	Block H3	Solar Probability Distributions

```
 8 SOLAR PROB DS         No. OF ENTRIES PER LINE AND THEN THE ENTRIES
 9  J                             11    200.       200.       200.       200.       200.       200.       200.
10  F                             11    200.       200.       200.       200.       200.       200.       200.
11  M                             11    200.       200.       200.       200.       200.       200.       200.
12  A                             11    200.       200.       200.       200.       200.       200.       200.
13  M                             11     68.       186.       280.       362.       420.       517.       596.
14  J                             11     60.       213.       321.       408.       461.       510.       560.
15  J                             11     70.       246.       386.       442.       511.       552.       578.
```

FORMAT: 20X, I10, 11F10.3

Enter the cumulative frequency distributions for solar radiation. Twelve distributions are required, one for each month. The following two parameters are required as input:

- The number of points in the cumulative frequency distribution.
- The actual values in the distribution. These values are in Langleys and are total daily solar radiation values. The number of values entered must equal the number of points specified by parameter 1 (No. of entries).

This block is not used in the current version of GRSM.

ERROR CHECK: SOLAR PROB D

Line 22-23	Block N1	Sunrise time for each month

```
21 SUN RISE   BY MONTH
22                          J          F          M          A          M          J          J
23                           0.33       0.31       0.27       0.24       0.21       0.20       0.21
24 DAYLENGTH
```

FORMAT:20X, 12F10.3

In this section, define the sunrise time for each month. Input requirements are the average time of sunrise expressed in units of fractions of a day, for each of the 12 months in the year. For example, 8:00 am = 8/24 = 0.333

ERROR CHECK: SUN RISE

Execution

<table>
<tr><td>Line 25-26</td><td>Block O1</td><td>Day length</td></tr>
<tr><td colspan="3"><pre>
24 DAYLENGTH
25   J   F   M   A   M   J   J
26   0.39   0.44   0.50   0.56   0.61   0.64   0.63
27 THERMAL
</pre></td></tr>
<tr><td colspan="3">FORMAT: 20X, 12F10.3</td></tr>
<tr><td colspan="3">This block further defines the solar radiation characteristics for the simulation. Enter the average daylight period, expressed as fractions of a day, for each of the 12 months in the year.</td></tr>
<tr><td colspan="3">ERROR CHECK: DAYLENGT</td></tr>
</table>

Temperature Parameters

GRSM is currently hard-coded to accept water temperature and solar radiation data from an external file (i.e., the METDATA file). The blocks with a grey background are not used by the model but **must** be included in the input file for the model to run properly.

Lines 28 – 87	Block I1	Reach Water Temperature Coefficients

```
27 THERMAL
28           1              0.00      0.00      0.00      0.00
29 REACH     2              0.00      0.00      0.00      0.00
30 REACH     3              0.00      0.00      0.00      0.00
31 REACH     4              0.00      0.00      0.00      0.00
32 REACH     5              0.00      0.00      0.00      0.00
33 REACH     6              0.00      0.00      0.00      0.00
34 REACH     7              0.00      0.00      0.00      0.00
```

FORMAT: 20X, 4F10.3

The user is required to enter the four reach water temperature coefficients for each reach. **This block is not used in the current version of GRSM.**

ERROR CHECK: THERMAL

Line 89	Block I3	Stream Temperature Regression Coefficients

```
87 REACH  60                0.00      0.00      0.00      0.00
88 STREAM TEMPERATURE COEFFICIENTS   -27
89  -27.25800   0.43240   0.00597  -0.00080   0.34600   0.00126
90 DAY VARIATION OF STREAM TEMPERATURES
91   -1.58480   0.01340   0.00450   0.00000   0.00210
```

FORMAT: 6F10.5

These values represent six empirically derived coefficients relating stream temperature to air temperature and sunlight intensity. **This block is not used in the current version of GRSM.**

ERROR CHECK: N/A

Line 91	Block I3	Daily Variation in Stream Temperature

```
89 -27.25800   0.43240   0.00597  -0.00080   0.34600   0.00126
90 DAY VARIATION OF STREAM TEMPERATURES
91   -1.58480   0.01340   0.00450   0.00000   0.00210
92 RATE FACTORS
```

FORMAT: 5F10.5

The user must enter five values defining a daily variation which is applied to the calculated stream temperature.

This block is not used in the current version of GRSM.

ERROR CHECK: DAY VARIATION

Line 93	Block J1	Arrhenius Rate Factors

```
90 DAY VARIATION OF STREAM TEMPERATURES
91   -1.58480   0.01340   0.00450   0.00000   0.00210
92 RATE FACTORS
93       1.0       1.040     1.065
94 DECAY RATES - temperature correction factors for NOD, Kr fo
95       1.080     1.065     1.065     1.045     1.045
```

FORMAT: 3F10.3

These values represent temperature correction factors for photosynthesis, sediment oxygen demand and respiration. These rate processes are adjusted for temperature effects using an Arrhenius-type correction factor of the form $\Theta^{(T-20)}$, where the value above represents Θ.

Note: The correction factors for photosynthesis and respiration are only applicable if the ECOL subroutine is not used.

ERROR CHECK: RATE FAC

Line 95	Block J2	Decay Rate Scale Factors

```
94 DECAY RATES - temperature correction factors for NOD, Kr for BOD decay and
95       1.080     1.065     1.065     1.045     1.045
96 HALF SATURATION CONSTANT FOR OXYGEN DEPENDENCE OF DENITRIFICATION
```

FORMAT: 6F10.3

Five values are required to account for temperature effects on: NOD decay rates, K_r for BOD decay and settling. K_d for BOD deoxygenation, NH_3 volatilization, and NO_3 denitrification. These rate processes are adjusted for temperature effects using an Arrhenius-type correction factor of the form $\Theta^{(T-20)}$, where the value above represents Θ

ERROR CHECK: DECAY RATES

Line 97	-	-
95 1.080 1.065 1.065 1.045 1.045 96 HALF SATURATION CONSTANT FOR OXYGEN DEPENDENCE OF DENITRIFICATION 97 2.00 98 STANDARD DEVIATION 12 PER REACH		
FORMAT: --		
Enter the half saturation constant for the oxygen dependence of denitrification. The denitrification rate used in GRCA is oxygen dependent and decreases as oxygen concentrations increase. The half-saturation coefficient represents the oxygen level at which the denitrification rate is half of the maximum rate under anaerobic conditions.		
ERROR CHECK: HALF SATURAT		

Reaeration Coefficient

Three coefficients are used to calculate K2. The coefficients must be entered for each reach and each month. Enter data for each reach one month at a time. Calculation of K2 is shown below:

$$K2 = \left(\frac{A \times VEL^{B}}{DEP^{C}} \right) \times 1.028^{(T\text{-}20)}$$

Where:

K2 = reaeration coefficient (1/sec)

VEL = stream velocity (ft/sec)

DEP = stream depth (ft)

T = stream temperature (°C)

A, B, C = empirical constants

If A = 12.9, B = 0.5 and C = 1.5, this equation reflects the O'Connor-Dobbins formula.

The coefficients of this equation must be entered in Imperial units.

To account for uncertainty in the value, the model allows for random variability to be added to the reaeration rate.

Line 99 – 158	Block J3	Standard Deviation of K2
97 2.00 98 STANDARD DEVIATION 12 PER REACH 99 REACH 1 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 100 REACH 2 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 101 REACH 3 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 102 REACH 4 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 103 REACH 5 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01		
FORMAT: 20X, 12F6.2		
Enter the standard deviation of the random component to be added to the reaeration coefficient (K2). Enter data for each reach, for each of the 12 months. **The default value is 0.01**. A higher value may be used if there is substantial uncertainty with respect to the reaeration rate.		
ERROR CHECK: STANDARD DEV		

Execution

Line 160 – 220	Block J4a	K2 Coefficients – A

		J	F	M	A	M	J	J	A	S	O	N	D
158	REACH 60	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
159	K2 COEFFICIENTS 12 MONTHS 3 PER REACH												
160	K2-A	J	F	M	A	M	J	J	A	S	O	N	D
161	REACH 1	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00
162	REACH 2	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00
163	REACH 3	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00
164	REACH 4	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00
165	REACH 5	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00
166	REACH 6	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00

FORMAT: 20X, 12F6.2

These values correspond to the constant A in the reaeration formula give above. For additional guidance, refer to the GRSM Technical Guidance Document, available under separate cover.

ERROR CHECK: K2 COEFF

Line 222 –281	Block J4b	K2 Coefficients – B

		J	F	M	A	M	J	J	A	S	O	N	D
220	REACH 60	41.00	41.00	41.00	41.00	41.00	41.00	41.00	41.00	41.00	41.00	41.00	41.00
221	K2-B	J	F	M	A	M	J	J	A	S	O	N	D
222	REACH 1	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
223	REACH 2	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
224	REACH 3	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
225	REACH 4	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
226	REACH 5	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50

FORMAT: 20X, 12F6.2

These values correspond to the constant B in the reaeration formula give above. For additional guidance, refer to the GRSM Technical Guidance Document, available under separate cover.

ERROR CHECK: N/A

Line 283 – 342	Block J4c	K2 Coefficients – C

		J	F	M	A	M	J	J	A	S	O	N	D
282	K2-C	J	F	M	A	M	J	J	A	S	O	N	D
283	REACH 1	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50
284	REACH 2	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50
285	REACH 3	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50
286	REACH 4	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50
287	REACH 5	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50
288	REACH 6	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50

FORMAT: 20X, 12F6.2

These values correspond to the constant C in the reaeration formula give above. For additional guidance, refer to the GRSM Technical Guidance Document, available under separate cover.

ERROR CHECK: N/A

Line 345 – 404	Block J9	Sediment Oxygen Demand

343 SEDIMENT OXYGEN DEMAND BASE RATES

	J	F	M	A	M	J	J	A	S	O	N	D
344												
345 REACH 1	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
346 REACH 2	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
347 REACH 3	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
348 REACH 4	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00

FORMAT: 20X, 12F10.3

The base rates for sediment oxygen demand (SOD) are entered in units of $gO_2/m^2/hr$. This rate should be the SOD at 20°C. Enter data for each reach, and each month. For additional guidance, refer to the GRSM Technical Guidance Document, available under separate cover.

ERROR CHECK: SEDIMENT OXY

Line 407 - 466	Block J10	BOD Removal Rates

405 CBOD DECAY RATE 12 PER REACH

	J	F	M	A	M	J	J	A	S	O	N	D
406												
407 REACH 1	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
408 REACH 2	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
409 REACH 3	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
410 REACH 4	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
411 REACH 5	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30

FORMAT: 20X, 12F10.3

This sub-block defines the carbonaceous BOD removal rate (K_R) at 20°C for each reach, and each month (d^{-1}). For additional guidance, refer to the GRSM Technical Guidance Document, available under separate cover.

ERROR CHECK: CBOD DECAY R

Line 469 – 528	Block J11	NOD Decay Rate

467 NOD DECAY RATE 12 PER REACH

	J	F	M	A	M	J	J	A	S	O	N	D
468												
469 REACH 1	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
470 REACH 2	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
471 REACH 3	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
472 REACH 4	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
473 REACH 5	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01

FORMAT: 20X, 12F10.3

Enter the nitrogenous oxygen demand decay rate (KN) at 20°C for each reach, and each month. For additional guidance, refer to the GRSM Technical Guidance Document, available under separate cover.

ERROR CHECK: NOD DECAY RA

Line 531 – 590	Block J12	BOD Deoxygenation Rate

529	ULTIMATE BOD DECAY RATE 12 PER REACH							
530		J	F	M	A	M	J	J
531	REACH 1	0.30	0.30	0.30	0.30	0.30	0.30	0.30
532	REACH 2	0.30	0.30	0.30	0.30	0.30	0.30	0.30
533	REACH 3	0.30	0.30	0.30	0.30	0.30	0.30	0.30
534	REACH 4	0.30	0.30	0.30	0.30	0.30	0.30	0.30
535	REACH 5	0.30	0.30	0.30	0.30	0.30	0.30	0.30
536	REACH 6	0.30	0.30	0.30	0.30	0.30	0.30	0.30

FORMAT: 20X, 12F10.3

Enter the deoxygenation rate for the biochemical oxygen demand (KD) at 20°C for each reach, and each month (d^{-1}). Typically, this value is equal to or slightly greater than the BOD decay rate (see above). For additional guidance, refer to the GRSM Technical Guidance Document, available under separate cover.

ERROR CHECK: ULTIMATE BOD

Line 593 – 652	Block J12	BOD5 to UBOD Conversion Factor

591	BOD5 TO UBOD CONVERSION RATE												
592		J	F	M	A	M	J	J	A	S	O	N	D
593	REACH 1	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50
594	REACH 2	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50
595	REACH 3	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50
596	REACH 4	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50
597	REACH 5	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50

FORMAT: 20X, 12F10.3

Enter the ratio of ultimate biochemical oxygen demand to BOD5 for each reach, and each month.

These parameters are no longer used in GRSM.

ERROR CHECK: BOD5 TO UBOD

Line 655 – 714	Block J14	Weir Aeration Rates

653	WEIR AERATION RATES 12 PER REACH							
654		J	F	M	A	M	J	J
655	REACH 1 Shand	0.50	0.50	0.50	0.50	0.10	0.10	0.10
656	REACH 2	1.00	1.00	1.00	1.00	1.00	1.00	1.00
657	REACH 3	1.00	1.00	1.00	1.00	1.00	1.00	1.00
658	REACH 4 Drimmie	0.50	0.50	0.50	0.50	0.50	0.50	0.50
659	REACH 5	1.00	1.00	1.00	1.00	1.00	1.00	1.00

FORMAT: 20X, 12F10.3

This sub-block contains the weir aeration rate (KW) values for each reach and each month. This allows the user to incorporate the effect of aeration/reaeration effects small weirs and dams in the simulated system. A value of one (1) is the default and represents no weirs. A value of 0.5 will allow aeration sufficient to reduce the DO deficit by 50%.

ERROR CHECK: WEIR AERATIO

Line 717 – 776	Block J15	Ammonia Volatilization Rates

```
715 AMMONIA VOLATILIZATION RATE CONSTANTS (EXPRESSED AS m/d)
716                            J        F        M        A        M        J        J
717 REACH  1                0.05     0.05     0.05     0.05     0.05     0.05     0.05
718 REACH  2                0.05     0.05     0.05     0.05     0.05     0.05     0.05
719 REACH  3                0.05     0.05     0.05     0.05     0.05     0.05     0.05
720 REACH  4                0.05     0.05     0.05     0.05     0.05     0.05     0.05
721 REACH  5                0.05     0.05     0.05     0.05     0.05     0.05     0.05
722 REACH  6                0.05     0.05     0.05     0.05     0.05     0.05     0.05
```

FORMAT: 20X, 12F10.3

This sub-block contains the ammonia volatilization rate values for each reach and each month. A default value of 0.05 d^{-1} is recommended. For additional guidance, refer to the GRSM Technical Guidance Document, available under separate cover.

ERROR CHECK: AMMONIA VOLA

Line 778	Block J16	Partial pressure of ammonia

```
776 REACH 60                0.05     0.05     0.05     0.05     0.05
777 PARTIAL PRESSURE OF AMMONIA IN AIR (ATM) - QUAL2K MANUAL GIVES RANGE OF 1
778           5.00E-09
779 DENITRIFICATION RATE CONSTANT (EXPRESSED AS 1/d)
```

FORMAT: 20X, F10.3

This value represents the partial pressure of ammonia in atmospheric air in atm. The default value is 5E-09 atm, Chapra, et al. (2008) gives a range of 1E-09 to 1E-08 atm for rural and moderately polluted areas and up to 1E-07 atm for heavily polluted areas. For additional guidance, refer to the GRSM Technical Guidance Document, available under separate cover.

ERROR CHECK: N/A

Line 781 – 840	Block J17	Denitrification Rates

```
779 DENITRIFICATION RATE CONSTANT (EXPRESSED AS 1/d)
780                            J        F        M        A        M        J        J
781 REACH  1                 1.0      1.0      1.0      1.0      1.0      1.0      1.0
782 REACH  2                 1.0      1.0      1.0      1.0      1.0      1.0      1.0
783 REACH  3                 1.0      1.0      1.0      1.0      1.0      1.0      1.0
784 REACH  4                 1.0      1.0      1.0      1.0      1.0      1.0      1.0
785 REACH  5                 1.0      1.0      1.0      1.0      1.0      1.0      1.0
```

FORMAT: 20X, 12F10.3

This sub-block contains the denitrification rate values for each reach and each month. A default value of 1.0 d^{-1} is recommended. For additional guidance, refer to the GRSM Technical Guidance Document, available under separate cover.

ERROR CHECK: DENITRIFICAT

Execution

4.4.5. FLOWFILE

FLOWFILE includes information defining boundary conditions of the inflow tributaries.

4.4.5.1. Template: RiverHydraulics.xls

You can use the **RiverHydraulics.xls** template to enter data more easily in the **Leopold-Maddock coefficients** section (block G1) of this input file. To use this template, consider the tips provided below.

- Determine the hydraulic coefficients by using the best available information from field studies, using dye tracers and/or hydraulic modeling.
- In column A, starting on row 2 with Reach 1, enter one row for each reach.
- The GRSM ignores the content of Column G. You can use this column to enter useful notes such as the source of the information, changes from previous versions, etc.
- When you are ready to generate the input file, follow these steps:
    1. Ensure the **HydraulicParameters** worksheet is selected then click **Save As**.
    2. From the **Save as type:** drop-down menu, select **Formatted Text (Space delimited) (*.prn)**.
    3. Open the PRN file with your preferred text editor.
    4. Select and copy (CTRL+C) the rows below HYDRAULIC PARAMETERS.
    5. Paste (CTRL+V) the data in Block G1 of the FLOWFILE input file.

4.4.5.2. Template: BoundaryQuality.xls

You can use the **BoundaryQuality.xls** template to enter data more easily in the **Boundary Inflow Water Quality Distribution** section (block K7) of this input file. To use this template, follow the steps described below.

1. For each boundary inflow and each water quality parameter (DO, BOD, NOD, NIT, TSS, and TP), determine the following statistical values and enter them in their respective columns:
    - Minimum value (column C)
    - 10^{th} percentile (column D)
    - 20^{th} percentile (column E)
    - 30^{th} percentile (column F)
    - 40^{th} percentile (column G)
    - 50^{th} percentile (column H)
    - 60^{th} percentile (column I)
    - 70^{th} percentile (column J)
    - 80^{th} percentile (column K)
    - 90^{th} percentile (column L)
    - Maximum value (column M)
2. Ensure the **BoundaryWQ** worksheet is selected then click **Save As**.

3. From the **Save as type:** drop-down menu, select **Formatted Text (Space delimited) (*.prn)**.
4. Open the PRN file with your preferred text editor.
5. Select and copy (CTRL+C) the rows below BOUNDARY.
6. Paste (CTRL+V) the data in Block K7 of the FLOWFILE input file.

4.4.5.3. File Description

Line 1	Block G1	Leopold Maddock Coefficients

```
HYDRAULIC PARAMETERS LEOPOLD MADDOX COEFFICIENTS
REACH  1               0.205    0.359    0.364    0.323
REACH  2               0.260    0.316    0.365    0.285
REACH  3               0.927    0.147    0.101    0.525
REACH  4               0.189    0.419    0.512    0.311
REACH  5               0.164    0.411    0.319    0.295
```

FORMAT: FREE

All blocks are preceded by a dummy line with the name of the section or headings. The dummy lines serve as error checks.

ERROR CHECK: HYDRAULI

Line 2 – 61	Block G1	Leopold Maddock Coefficients

```
HYDRAULIC PARAMETERS LEOPOLD MADDOX COEFFICIENTS
REACH  1               0.205    0.359    0.364    0.323
REACH  2               0.260    0.316    0.365    0.285
REACH  3               0.927    0.147    0.101    0.525
REACH  4               0.189    0.419    0.512    0.311
REACH  5               0.164    0.411    0.319    0.295
```

FORMAT: 20X, 4F10.3

Enter the Leopold-Maddock coefficients that will be used by GRSM to estimate depth and velocity of the river under different flow conditions. The relationships are based on the Leopold-Maddock coefficients linking flow, depth and velocity. Four coefficients (a, b, c, d) for each reach of the system are required. These values are derived from non-linear regression of velocity and depth over a range of flow conditions. Depths and velocities can be based on field measurements but this is often impractical and a hydraulic model may be useful in this case. The methods of calculation employed in the GRSM are outlined below:

$D = aQ^b$ $\quad\quad$ $V = cQ^d$

Where:

- V = velocity (feet/second)?
- Q = streamflow (cubic feet per second)
- D = depth (feet)?
- a, b, c, d = the empirically derived coefficients that are entered into the input file

ERROR CHECK: HYDRAULI

Execution

Line 63 – 100	Block D1	Local Inflow Distribution

```
62 LOCAL_IN
63 Reach 4                          0.01
64 Reach 7                          0.02
65 Reach 8                          0.01
66 Reach 10                         0.04
67 Reach 12                         0.02
```

FORMAT: 20X, F10.3

In this sub-block, enter the fraction of the total local diffuse inflow that is received by each reach. The number of rows in this block must equal the number of local diffuse inflows indicated in the BASICS block (i.e., row 2 of MAINFILE). The total of all fractions should be 1. The calculation of the local diffuse inflow for each reach is determined using the following equation:

$L1_J = TBI * F_J$

Where:

$L1_J$ = local diffuse inflow (cubic feet per second)

TBI = total basin local diffuse inflow (cubic feet per second), these are the values that appears in the last column of the BASINFLOW file

F_J = fraction of total local diffuse inflow that is received by reach J

ERROR CHECK: N/A

Line 103-117	Block K1	Type of Calculation to Use

```
102 TYPE OF CALCULATION TO BE USED
103 SHAND DAM             4  4  4  4  4  4
104 IRVINE CREEK          4  4  4  4  4  4
105 CARROLL CREEK         4  4  4  4  4  4
106 SWAN CREEK            4  4  4  4  4  4
107 COX CREEK             4  4  4  4  4  4
108 CANAGAGIGUE           4  4  4  4  4  4
109 CONESTOGO             4  4  4  4  4  4
110 LAUREL                4  4  4  4  4  4
111 SCHNEIDERS            4  4  4  4  4  4
112 SPEED RIVER           4  4  4  4  4  4
113 ERAMOSA               4  4  4  4  4  4
114 NITH RIVER            4  4  4  4  4  4
```

FORMAT:20X, 6I3

This sub-block defines the calculation type used by GRSM for boundary inflow water quality. The user can choose from one of six calculation types:

- **Type 1:** Quality is constant and independent of flow. The quality is set equal to the first value contained in the quality distributions provided in Block K7.

- **Type 2:** Quality is variable and dependent on flow. In this case, the user specifies, in Block K5, the number of equally spaced flow intervals between the maximum flow and minimum flow specified in Blocks K2 and K3 and the concentration associated with each interval. Up to 10 intervals can be specified. The model determines which flow interval the current boundary flow is in and assigns the concentration equal to the first value in the water quality distributions given in Block K7 based on the map given in Block K9 (i.e., the map tells the model which distribution to use for each flow interval).
- **Type 3:** Quality is variable and is chosen from a probability distribution which is dependent on flow. This approach is similar to Type 2, except that the quality is determined probabilistically based on the distribution given in Block K7.
- **Type 4:** Quality is variable and is chosen from a probability distribution which is independent of flow. This approach is similar to Type 2, except that the quality is determined probabilistically based on the distributions given in Block K7 and the map given in Block K9 (i.e., the map tells the model which distribution to use for each flow interval).
- **Type 5:** Quality is variable and is chosen from a distribution which is conditional on a probability distribution given in Type 3. To specify a Type 5, one of the previous quality parameters must be estimated using Type 3.
- **Type 6:** Quality is variable and is chosen from a distribution which is conditional on a probability distribution given in Type 4. To specify a Type 6, one of the previous quality parameters must be estimated using Type 4.

Enter an integer value for each water quality parameter corresponding to one of the probability distribution types for each of the boundary inflows and the total basin local diffuse inflow. For example, if the system has four boundary inflows and six water quality parameters, then 18 values must be entered. The default value for this input is Type 4. The quality of local diffuse inflow is calculated in **the current version of GRSM** as either Type 1 or Type 2 only, see Block M1.

ERROR CHECK: TYPE OF CALC

Line 119-133	Block B1	Regulated Minimum Flow Policy

118	REG_FLOW_MINIMUM	J	F	M	A	M	J	J
119	SHAND DAM	000.	000.	000.	000.	000.	000.	000.
120	IRVINE CREEK	000.	000.	000.	000.	000.	000.	000.
121	CARROLL CREEK	000.	000.	000.	000.	000.	000.	000.
122	SWAN CREEK	000.	000.	000.	000.	000.	000.	000.
123	COX CREEK	000.	000.	000.	000.	000.	000.	000.
124	CANAGAGIGUE	000.	000.	000.	000.	000.	000.	000.
125	CONESTOGO	000.	000.	000.	000.	000.	000.	000.

FORMAT: 2X12F10.3

This sub-block allows the user to specify a minimum regulated flow policy for the boundary inflows. This allows the user to incorporate the effects of changing the operating policy at an existing upstream reservoir or to add additional upstream reservoirs without having to create a new input file for the boundary location flows.

Specify the minimum regulated flow in cubic feet per second for each reach of the boundary flows, for each month. There is a minimum of 12 columns of code in this sub-block (one column per month). If no regulation policy is required for a particular flow for a particular month, enter 000.

ERROR CHECK: N/A

Execution

Line 136-150	Block K2	Largest Expected Boundary Inflow

134	LARGEST EXPECTED FLOW 12 PER BOUNDARY FLOW							
135		J	F	M	A	M	J	J
136	SHAND DAM	6000.	6000.	6000.	6000.	6000.	6000.	6000.
137	IRVINE CREEK	6000.	6000.	6000.	6000.	6000.	6000.	6000.
138	CARROLL CREEK	6000.	6000.	6000.	6000.	6000.	6000.	6000.
139	SWAN CREEK	6000.	6000.	6000.	6000.	6000.	6000.	6000.

FORMAT: 20,12F10.3

Enter the highest expected flow (cubic feet per second) for each boundary flow (including basin local diffuse inflow) for each month. Twelve values for each flow must be entered. GRSM uses these values to calculate flow intervals when calculation Type 2, 3 or 5 is specified.

ERROR CHECK: LARGEST EXPE

Line 153-167	Block K3	Minimum Expected Boundary Inflow

151	MINIMUM EXPECTED FLOW 12 PER BOUNDARY FLOW							
152		J	F	M	A	M	J	J
153	SHAND DAM	000.	000.	000.	000.	000.	000.	000.
154	IRVINE CREEK	000.	000.	000.	000.	000.	000.	000.
155	CARROLL CREEK	000.	000.	000.	000.	000.	000.	000.
156	SWAN CREEK	000.	000.	000.	000.	000.	000.	000.

FORMAT: 20X, 12F10.3

This sub-block is similar to the previous sub-block, except that the data required are the minimum expected flow (cubic feet per second) for each boundary inflow (including basin local diffuse inflow) for each of the 12 months. GRSM uses these values to calculate flow intervals when calculation Type 2, 3 or 5 is specified. The lowest allowable flow is 0 cubic feet per second.

ERROR CHECK: MINIMUM EXPE

Line 170-259	Block K4	Within Day Variation of Boundary Inflows

```
168 WITHIN DAY VARIATION OF FLOW 12 PER PARAMETER PER INFLOW
169                             1         2         3         4         5         6
170 SHAND DAM          1        1.        1.        1.        1.        1.        1.
171 SHAND DAM          2        1.        1.        1.        1.        1.        1.
```

FORMAT: 20X, 12F10.3

Input data for this sub-block are dependent upon the options selected by the user in positions 11 and 13 of sub-block 3 in the MAINFILE BASICS block. Positions 11 and 13 correspond to the boundary inflow quality and the local diffuse inflow quality respectively. If the flags are turned on (set to 1) the data will be read from an external file; if turned off (set to 0), the data will be entered in this sub-block. Regardless of the choice, the user must enter a within-day-variation factor for each of the flows including the local inflow, for each quality parameter, for each of the 12 time steps. If external input is selected, then actual values must be entered in the BASINFLOW file. Values of 1.0 should be entered if internal calculation is selected (as is shown in this example above).

ERROR CHECK: WITHIN DAY V

Line 262-351	Block K5	Boundary Inflow Subintervals

```
260 SUB-INTERVALS OF BOUNDARY INFLOWS 12 PER PARAMETER PER INFLOW
261                       J  F  M  A  M  J  J  A  S  O  N  D
262 SHAND DAM          DO 1  1  1  1  1  1  1  1  1  1  1  1
263 SHAND DAM         BOD 1  1  1  1  1  1  1  1  1  1  1  1
264 SHAND DAM         NOD 1  1  1  1  1  1  1  1  1  1  1  1
265 SHAND DAM          NI 1  1  1  1  1  1  1  1  1  1  1  1
266 SHAND DAM          SS 1  1  1  1  1  1  1  1  1  1  1  1
267 SHAND DAM          TP 1  1  1  1  1  1  1  1  1  1  1  1
```

FORMAT: 20X, 12I3

Enter the number of flow subintervals between the lowest and highest boundary inflows and total basin local diffuse inflow for each water quality parameter for the 12 months. Input to this sub-block depends upon the probability distribution type selected earlier in Block K1. If type 1, 4 or 6 is selected, values of 1.0 must be entered. If type 2, 3 or 5 is selected, then the desired number of flow interval partitions must be entered. The maximum number of sub-intervals allowed is 10.

ERROR CHECK: SUB-INTERVAL

Line 352-353	Block K6	Number of Boundary Inflow Water Quality Distributions to Read

```
351 LOCAL INFLOW       TP  1  1  1  1  1  1  1  1  1  1  1  1
352 NUMBER OF LINES TO READ IN NEXT SECTION
353  90
354 BOUNDARY FLOW WATER QUALITY DISTRIBUTIONS
```

FORMAT: I3

Enter the number of lines the GRSM should expect to read in the next block. The number of lines is equal to the number of boundary inflows simulated (15, in this example) multiplied by the number of water quality parameters (6) multiplied by the number of flow subintervals (1 in this case because the calculation type is set to 4, which means water quality does not vary with flow).

ERROR CHECK: NUMBER OF LI

Line 356-445	Block K7	Boundary Inflow Water Quality Distribution

```
354 BOUNDARY FLOW WATER QUALITY DISTRIBUTIONS
355   INFLOW    PARAMETER  NO.    DISTRIBUTION INCREMENTS OF 10%
356 Belwood     DO                11     7.580     8.358     8.752     9.092     9.572    10.340    10.570    10.942    11.550    12.368    14.800
357 Belwood     BOD               11     0.500     0.590     0.800     0.800     0.920     1.100     1.600     1.800     1.840     2.110     2.700
358 Belwood     NOD               11     2.925     3.236     3.364     3.428     3.528     3.610     3.729     3.775     3.976     4.241     4.707
359 Belwood     NO3               11     0.015     0.124     0.254     0.393     0.461     0.612     0.666     0.853     1.019     1.136     1.580
360 Belwood     TSS               11     2.500     3.480     3.820     4.320     5.020     5.500     6.680     7.340     7.940    11.020    14.600
```

FORMAT: 20X, I10, 11F10.3

The following information is required: the number of points in the quality probability distribution (N) and the N values in the quality probability distribution arranged in ascending order. In this case, the probability distribution is defined by the minimum value for each parameter followed by the 10^{th} percentile, 20^{th} percentile and so on, until the last value is the maximum value. These distributions are ideally based on field measured concentrations over a representative period.

The number of quality probability distributions to be input is defined by the value entered in the previous sub-block. The probability distribution should be entered for each boundary flow for each quality parameter. The last set of probability distributions entered defines the quality of the total basin local diffuse inflow. Internal calculation of quality proceeds according to the following procedure.

The model calls the random number generator which generates a random number between 0 and 1.

The model enters the cumulative frequency distribution input by the user and selects the values from the distribution which are in the distribution positions one higher and one lower than the random number.

The model then employs a linear interpolation technique to calculate the exact value which corresponds to the generated random number.

The current version of GRSM does not use the probability distribution to estimate quality of local diffuse inflow, see Block M1 below.

ERROR CHECK: BOUNDARY FLO

Execution

Line 446-447	Block K9	Boundary Inflow Subinterval Quality Distribution Map

```
445 LOCAL INFLOW TP            11      0.004      0.01
446 MAP FOR QUALITY DISTRIBUTIONS
447                          8  6
448 SHAND DAM             DO  1  0  0  0  0  0  0  0  0  0
449 SHAND DAM            BOD  2  0  0  0  0  0  0  0  0  0
```

FORMAT: FREE

The number 8 must appear in the column (x) of the first line of each month. The number of the month (6, 7, 8 or 9) must appear in column (y), i.e., line 447 for month of June reads 8 in column (x) and 6 in column (y).

ERROR CHECK: MAP FOR QUALITY

Line 448-810	Block K9	Boundary Inflow Subinterval Quality Distribution Map

```
446 MAP FOR QUALITY DISTRIBUTIONS
447                          8  6
448 SHAND DAM             DO  1  0  0  0  0  0  0  0  0  0
449 SHAND DAM            BOD  2  0  0  0  0  0  0  0  0  0
450 SHAND DAM            NOD  3  0  0  0  0  0  0  0  0  0
451 SHAND DAM        NO2+NO3  4  0  0  0  0  0  0  0  0  0
452 SHAND DAM             SS  5  0  0  0  0  0  0  0  0  0
453 SHAND DAM             TP  6  0  0  0  0  0  0  0  0  0
```

FORMAT: 20X, 10I3

This block of input is used to specify the water quality distributions in order to calculate boundary water quality. It tells GRSM which quality probability distribution corresponds to each flow interval for each month of the simulation period. Ten values are required for each boundary flow for each quality parameter, including the total basin local diffuse inflow. Each of the 10 values refers to the row number of the quality probability distribution entered in Block K7 of this control file. For Type 1, 4 or 6 calculations, there is only one flow interval and the first column should consist of a series of numbers from 1 to the maximum number of distributions given in Block K6, e.g., 90 in this case. The remaining nine values are either assigned a distribution number (e.g., for Type 2, 3 or 5 calculations where boundary quality is dependent on flow) or set equal to 0 (e.g., for Type 1, 4 or 6 calculations). The number of values required depends upon the number of flow intervals defined by the user in Block K5 of this control file.

Lines 448 – 537 June

Lines 539 – 628 July

Lines 630 – 719 August

Lines 721 – 810 September

ERROR CHECK: N/A

Execution

Line 811-812		Order of Local Diffuse Inflow Water Quality Parameters

```
810 LOCAL INFLOW        TP 90   0   0   0   0   0   0   0   0   0
811 QUALITY ORDER OF LOCAL INFLOW WATER QUALITY PARAMETERS
812                          2  1  3  4  5  6  7  8  9 10
813 MODIFY    LOCAL INFLOW WATER QUALITY
```

FORMAT: 20X, 10I3

The order in which the water quality parameters are to be calculated in the GRSM is specified in this sub-block. Ten values must be entered, one for each of the 10 possible water quality parameters. The numerical assignments for each of the water quality parameters is outlined below:

1 – DO	5 – SS
2 – BOD	6 – TP
3 – NOD	7 – Un-ionized NH_3+
4 – NIT	8-10 – Not presently used

The current version of the model ignores this line; the order of water quality parameters is hard-coded into the model in the following order: DO, BOD, NOD, NIT, SS, TP, Un-ionized Ammonia.

ERROR CHECK: QUALITY ORDE

Line 815-1042	Block M1	Modify Local Diffuse Inflow Quality

```
813 MODIFY    LOCAL INFLOW WATER QUALITY
814  REACH        PARAMETER       A          B          C
815 LOCAL 1     DO               8.4
816             BOD              7.2
817             NOD              8.7
818             NO2+NO3          3.1
819             SS                18
820             TP              0.19
821 LOCAL 2     DO               8.4
822             BOD              7.2
823             NOD              8.7
```

FORMAT: 20X, 3F10.3

This sub-block allows the user to specify the quality of the local diffuse inflow for each reach in the system. The quality of the local diffuse inflow can be either Type 1 (constant) or Type 2 (variable depending on flow). Input requirements are three coefficients for each quality parameter for each reach. The coefficients are used in the GRSM as illustrated by the following equation.

$$LIQ = (A + B \times LDI + C \times LDI^2) \times Y_I$$

Execution

Where: LIQ = local diffuse inflow quality (mg/L) LDI = local diffuse inflow volume (cubic feet per second) A, B, C = quality coefficients Y_I = within day variation factor for time step I (unitless, these values are specified in the next block) To set the quality of local diffuse inflow to be constant, A = the concentration of each parameter, B and C are set equal to 0 and Y_I = 1. If the quality of one or more parameter is known to be flow dependent, the user must determine the appropriate values of B and C.
ERROR CHECK: MODIFY

Line 1043	Block M2	Daily Variation of Local Inflow Quality

```
1043 DAILY VARIATION
1044 LOCAL 1             DO      1.        1.        1.        1.        1.        1.        1.
1045 LOCAL 1            BOD      1.        1.        1.        1.        1.        1.        1.
1046 LOCAL 1            NOD      1.        1.        1.        1.        1.        1.        1.
1047 LOCAL 1        NO2+NO3      1.        1.        1.        1.        1.        1.        1.
```

FORMAT: 20X, 12F10.3
This sub-block allows for the incorporation of a diurnal variation in the local inflow quality for each reach (i.e., Y_I in the equation above). Enter a variation factor for each reach, for each water quality parameter, for each of the 12 time steps in each day. If no diurnal variation is required, all values should be set to 1.
ERROR CHECK: DAILY VARIAT

4.4.6. STPFLOW

STPFLOW relates to the point source (water pollution control plant) data and specifies the values to be used by GRSM to calculate **point source flow** using internal subroutines and **point source quality** using probability distributions.

Internal calculation of WWTP flows is specified by setting the switch in position 3 equal to 0 on line 5 of the BASICS block in MAINFILE. Otherwise, WWTP flows are read in from the STP_FLOW_FILE (see below).

Similarly, WWTP effluent quality is estimated using probability distribution functions by setting the switch in position 12 on line 5 of the BASICS block equal to 0.

Daily flow data are typically available and can be specified in an external file, whereas effluent quality is typically measured less frequently and it is more appropriate to specify this as a probability distribution function.

4.4.6.1. Template: WWTP_Qual.xls

You can use the **WWTP_Qual.xls** template to enter data more easily in the **Point Source Water Quality** section (block L7) of this input file. To use this template, follow the steps described below.

1. Do not modify the first row as it is a comment line required by the GRSM.
2. In the second row, enter the number of rows the GRSM should expect to read in this section.

$$\#\text{ of rows} = \#\text{ of WWTP} \times 6$$

3. For each WWTP and each effluent parameter (DO, BOD, NOD, NIT, SS and TP), determine the following statistical values and enter them in their respective columns:
   - Minimum value (column D)
   - 10th percentile (column E)
   - 20th percentile (column F)
   - 30th percentile (column G)
   - 40th percentile (column H)
   - 50th percentile (column I)
   - 60th percentile (column J)
   - 70th percentile (column K)
   - 80th percentile (column L)
   - 90th percentile (column M)
   - Maximum value (column N)

Do not change the order of the effluent parameters as they appear in this template.

4. Ensure the **WWTP_Qual** worksheet is selected then click **Save As**.
5. From the **Save as type:** drop-down menu, select **Formatted Text (Space delimited) (*.prn)**.
6. Open the PRN file with your preferred text editor.
7. Select and copy (CTRL+C) all the rows.
8. Paste (CTRL+V) the data in Block L7 of the STPFLOW input file.

4.4.6.2. File Description

Point Source Flow

Line 1	Block C21	New Point Source (WWTP) Flow Rates

```
1 STPFLOW                 FLOWS TO BE MODELLED (CFS)
2 FERGUS                          0.0
3 ELORA                           0.0
```

FORMAT: FREE
All blocks are preceded by a dummy line with the name of the section or headings. The dummy lines serve as error checks.
ERROR CHECK: STPFLOW

Line 2 – 11	Block C21	New Point Source (WWTP) Flow Rates

```
1 STPFLOW                 FLOWS TO BE MODELLED (CFS)
2 FERGUS                          0.0
3 ELORA                           0.0
4 WATERLOO                       16.507
5 KITCHENER                      28.689
6 GUELPH                         23.0616
7 HESPELER                        2.2648
8 PRESTON                         4.1125
9 GALT                           13.574
10 PARIS                          0.69
11 BRANTFORD                     17.35
```

FORMAT: 20X, F10.3
Enter the WWTP name (up to 20 characters) followed by its flow in cubic feet per second. This value will be factored using the original database that follows. This block is only used by GRSM when WWTP flows are calculated internally, i.e., flag set to 0 in position 3 of line 5 in BASICS block. This block only applies when WWTP flows are calculated internally but must contain one row for each WWTP, regardless of whether the flows are calculated internally or read in from an external file.
ERROR CHECK: STPFLOW

Line 13-22	Block C1	Original WWTP Flow Rate and Coefficient Database

12	STPFLOW DO NOT TOUCH BASE FLOW	A1	A2	A3	B1	B2	B3	B4	B5	B6
13	FERGUS 0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
14	ELORA 0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15	WATERLOO 16.507	16.5068	-0.0068	0.0001	-2.9569	0.6952	1.2359	0.1344	1.4920	0.8796
16	KITCHENER 28.689	45.9090	-0.1256	0.0001	-3.5752	0.0000	0.0000	1.6428	1.3491	1.7221
17	GUELPH 23.0616	49.1150	-0.2558	0.0005	-2.5070	0.0000	1.3917	1.1204	0.7819	0.6385
18	HESPELER 2.2648	2.0850	0.0147	-0.0001	-0.1713	0.0000	0.1461	0.0000	0.1862	0.0000
19	PRESTON 4.1125	3.2260	0.0049	0.0000	-0.7994	0.2992	0.4296	0.3579	0.2002	0.0000
20	GALT 13.574	22.512	-0.0791	0.0002	-2.1433	0.9527	1.2990	1.2435	0.0000	0.0000
21	PARIS 0.69	0.757	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22	BRANTFORD 17.35	35.0720	-0.1648	0.0003	-3.2518	0.0	0.9325	1.4147	1.2074	1.1954

FORMAT: 20X, 10F10.4

This sub-block defines the base flow and nine regression coefficients used in the pre-1995 GRSM to calculate the point source flows. The regression coefficients describe how the flows vary from day to day during the week. This block only applies when WWTP flows are calculated internally but must contain one row for each WWTP, regardless of whether the flows are calculated internally or read in from an external file.

The 10 values required per line are as follows:

Base flow in cubic feet per second. Use a value that has been calculated using the monthly average flow value over the year to determine the seasonal trend of the flow. A parabolic relationship has been assumed, although a linear or constant value can be used.

A1-A3. The three regression coefficients for each point source that determine how WWTP flows change depending on the time of year.

B1-B6. The six daily variation factors for each point source that describe how flows vary throughout the week. It is assumed that the lowest WWTP flows occur on Saturdays.

The algorithms for internal calculation of point source inflows are:

For Saturday: $Q = A_1 + A_2 \times IDY + A_3 \times IDY^2 - B_1 - B_2 - B_3 - B_4 - B_5 - B_6$

For other days: ${}_iQ_i = A_1 + A_2 \times IDY + A_3 \times IDY^2 + B_i$ where i is the day of the week, e.g., 1 =Sunday, 2 = Monday, 3 = Tuesday, etc.

Where:

Q = flow (cubic feet per second)

IDY = Julian day

A_1, A_2, A_3 = regression coefficients

B_1, B_2, B_3, B_4, B_5, B_6 = daily variation factors for Sunday, Monday, Tuesday, etc.

The WWTP flow is multiplied by a scaling factor equal to NEWSTPFLOW/STPBASEFLOW, where NEWSTPFLOW is input in Block C21 and STPBASEFLOW is input in Block C1.

ERROR CHECK: STPFLOW DO N

Line 24-33	Block C2	Standard Deviations of Point Source (WWTP) Flow

```
23 STPFLOW STANDARD DEVIATIONS 1 PER PLANT
24 FERGUS                  0.000
25 ELORA                   0.000
26 WATERLOO                0.000
27 KITCHENER               0.000
28 GUELPH                  0.000
29 HESPELER                0.000
30 PRESTON                 0.000
31 GALT                    0.000
32 PARIS                   0.000
33 BRANTFORD               0.000
```

FORMAT: 20X, F10.3

The user must specify a standard deviation in cubic feet per second for each of the point source flows, one per source per line. Specifying a standard deviation will introduce random variability into the WWTP flows used in GRSM. This block only applies when WWTP flows are calculated internally but must contain one row for each WWTP, regardless of whether the flows are calculated internally or read in from an external file.

ERROR CHECK: STPFLOW STAN

Line 35-44	Block C3	WWTP Daily Flow Variations Diurnal Curve

```
34 STPFLOW DAILY VARIATIONS EACH TIMESTEP PER DAY
35 FERGUS          1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00
36 ELORA           1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00
37 WATERLOO        0.77  0.61  0.61  0.83  1.23  1.32  1.26  1.13  1.08  1.13  1.08  0.99
38 KITCHENER       0.99  0.81  0.73  0.74  0.98  1.13  1.16  1.15  1.10  1.09  1.10  1.05
39 GUELPH          0.92  0.75  0.70  0.74  0.92  1.22  1.24  1.23  1.11  1.09  1.05  1.01
40 HESPELER        1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00
41 PRESTON         0.92  0.75  0.72  0.72  0.96  1.19  1.28  1.20  1.10  1.10  1.06  1.02
42 GALT            0.85  0.75  0.68  0.78  0.99  1.25  1.21  1.15  1.15  1.11  1.08  1.08
43 PARIS           1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00
44 BRANTFORD       0.95  0.80  0.71  0.71  0.99  1.19  1.25  1.23  1.12  1.05  1.03  1.11
```

FORMAT: 20X, 12F10.2

Twelve values are required, one for each time step of each day, to represent the within-day variation factors for each point source flow. These values can be used to reproduce diurnal variability in the WWTP flows instead of or in addition to the regression formula given in Block C1. This block only applies when WWTP flows are calculated internally but must contain one row for each WWTP, regardless of whether the flows are calculated internally or read in from an external file.

ERROR CHECK: STPFLOW DAIL

Line 47-106	Block L1	Within-Day Point Source Quality Variations

46	WITHIN DAY VARIATIONS OF WATER QUALITY EACH TIMESTEP PER SOURCE PER PARAMETER													
47	FERGUS	DO	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
48	FERGUS	BOD	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
49	FERGUS	NOD	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
50	FERGUS	NO2+NO3	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
51	FERGUS	SS	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

FORMAT: 20X, 12F10.3

Twelve values are required, one for each time step of each day, to represent the within-day variation factors for each point source effluent quality. These values can be used to reproduce diurnal variability in the WWTP quality for any parameter from any of the WWTPs. The default value is 1.0, which means there is no variation.

ERROR CHECK: WITHIN DAY V

Line 109-118	Block L2	Lowest Expected Point Source (WWTP) Flows

107	LOWEST EXPECTED POINT SOURCE FLOW PER MONTH												
108		J	F	M	A	M	J	J	A	S	O	N	D
109	FERGUS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
110	ELORA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
111	WATERLOO	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
112	KITCHNER	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
113	GUELPH	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
114	HESPELER	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
115	PRESTON	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
116	GALT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

FORMAT: 20X, 12F10.3

The user must enter the lowest expected point source flow (cubic feet per second) for each month. Twelve values must be entered for each point source. The lowest allowable flow is 0 cubic feet per second. GRSM uses these values to calculate flow intervals when calculation Type 2, 3 or 5 is specified.

ERROR CHECK: LOWEST EXPEC

Line 121-130	Block L3	Maximum Expected Point Source (WWTP) Flows

119	MAXIMUM EXPECTED POINT SOURCE FLOW PER MONTH												
120		J	F	M	A	M	J	J	A	S	O	N	D
121	FERGUS	150.0	150.0	150.0	150.0	150.0	150.0	150.0	150.0	150.0	150.0	150.0	150.0
122	ELORA	150.0	150.0	150.0	150.0	150.0	150.0	150.0	150.0	150.0	150.0	150.0	150.0
123	WATERLOO	150.0	150.0	150.0	150.0	150.0	150.0	150.0	150.0	150.0	150.0	150.0	150.0
124	KITCHENER	150.0	150.0	150.0	150.0	150.0	150.0	150.0	150.0	150.0	150.0	150.0	150.0
125	GUELPH	150.0	150.0	150.0	150.0	150.0	150.0	150.0	150.0	150.0	150.0	150.0	150.0
126	HESPELER	150.0	150.0	150.0	150.0	150.0	150.0	150.0	150.0	150.0	150.0	150.0	150.0
127	PRESTON	150.0	150.0	150.0	150.0	150.0	150.0	150.0	150.0	150.0	150.0	150.0	150.0
128	GALTL	150.0	150.0	150.0	150.0	150.0	150.0	150.0	150.0	150.0	150.0	150.0	150.0

FORMAT:20X, 12F10.3

This sub-block is similar to Block L2, except that the data required are the maximum expected point source flows (cubic feet per second) for each of the 12 months. GRSM uses these values to calculate flow intervals when calculation Type 2, 3 or 5 is specified.

ERROR CHECK: MAXIMUM EXPE

Execution

Point Source Quality

Line 132-141	Block L4	Calculation Choice

```
131 CHOICE OF CALCULATION
132 FERGUS                4  4  4  4  4  4
133 ELORA                 4  4  4  4  4  4
134 WATERLOO              4  4  4  4  4  4
135 KITCHENER             4  4  4  4  4  4
136 GUELPH                4  4  4  4  4  4
137 HESPELER              4  4  4  4  4  4
138 PRESTON               4  4  4  4  4  4
139 GALTL                 4  4  4  4  4  4
140 PARIS                 4  4  4  4  4  4
141 BRANTFORD             4  4  4  4  4  4
```

FORMAT: 20X, 6I3

This feature defines the probability distribution type used by the GRSM to calculate the point source water quality. It is similar to the approach used for boundary quality conditions described in Block K1. Enter an integer value corresponding to one of the following six types for each water quality parameter for each of the point source inflows.

Type 1: Quality is constant and independent of flow. The quality is set equal to the first value contained in the quality distributions provided in Block K7.

Type 2: Quality is variable and dependent on flow. In this case, the user specifies, in Block K5, the number of equally spaced flow intervals between the maximum flow and minimum flow specified in Blocks K2 and K3 and the concentration associated with each interval. Up to 10 intervals can be specified. The model determines which flow interval the current boundary flow is in and assigns the concentration equal to the first value in the water quality distributions given in Block K7 based on the map given in Block K9 (i.e., the map tells the model which distribution to use for each flow interval).

Type 3: Quality is variable and is chosen from a probability distribution which is dependent on flow. This approach is similar to Type 2, except that the quality is determined probabilistically based on the distribution given in Block K7.

Type 4: Quality is variable and is chosen from a probability distribution which is independent of flow. This approach is similar to Type 2, except that the quality is determined probabilistically based on the distributions given in Block K7 and the map given in Block K9 (i.e., the map tells the model which distribution to use for each flow interval).

Type 5: Quality is variable and is chosen from a distribution which is conditional on a probability distribution given in Type 3. To specify a Type 5, one of the previous quality parameters must be estimated using Type 3.

Type 6: Quality is variable and is chosen from a distribution which is conditional on a probability distribution given in Type 4. To specify a Type 6, one of the previous quality parameters must be estimated using Type 4.

The default value for this input is Type 4.

ERROR CHECK: CHOICE OF CA

Line 144-203	Block L5	Subintervals between High and Low Flows

```
142 SUBINTERVALS OF POINT SOURCELOWS 12 PER PARAMETER PER INFLOW
143                               J  F  M  A  M  J  J  A  S  O  N  D
144 FERGUS                   DO   1  1  1  1  1  1  1  1  1  1  1  1
145 FERGUS                  BOD   1  1  1  1  1  1  1  1  1  1  1  1
146 FERGUS                  NOD   1  1  1  1  1  1  1  1  1  1  1  1
147 FERGUS                   NI   1  1  1  1  1  1  1  1  1  1  1  1
148 FERGUS                   SS   1  1  1  1  1  1  1  1  1  1  1  1
```

FORMAT: 20X,12I3

The required inputs are the number of sub-intervals between the lowest and highest flows for each of the point source, for each water quality parameter simulated, and for each of the 12 months. Input to this sub-block depends upon the type of calculation selected in the previous block. If type 1, 4, or 6 is selected, then values of 1 must be entered. If type 2, 3 or 5 is selected, then the number of flow interval partitions for each month, up to a maximum of 10, must be entered.

ERROR CHECK: SUBINTERVALS

Line 204-205	Block L6	Number of Lines to Read for WWTP Water Quality

```
203 BRANTFORD           TP   1   1   1   1   1   1
204 LINES TO READ IN STP EFFLUENT QUALITY
205 60
```

FORMAT: FREE

Enter the number of quality probability distributions which will be entered in the next sub-block. This number is calculated by multiplying the # of point source inputs (NTF), the # of water quality parameters simulated (NQP), and the total # of flow subintervals as defined above. In this example, we have six water quality parameters and 10 WWTPs with only one flow subinterval (e.g., calculation Type 4).

ERROR CHECK: LINES TO REA

Line 208-267	Block L7	Point Source Water Quality

```
206 POINT SOURCE WATER QUALITY
207 SOURCE PARAMETER   NO.0   INCREMENTS OF 10%
208 FERGUS    DO          11    4.000    4.000    4.000    4.000    4.000    4.000    4.000    4.000    4.000    4.000    4.000
209 FERGUS    BOD         11    1.200    1.490    1.790    1.800    2.000    2.150    2.500    2.600    2.700    2.820    4.000
210 FERGUS    NOD         11    0.411    0.411    0.448    0.457    0.457    0.457    0.457    0.484    0.914    1.069    2.742
211 FERGUS    NO2+NO3     11   15.270   18.287   20.360   20.612   21.012   21.375   21.600   22.580   23.400   23.797   23.980
212 FERGUS    SS          11    1.000    2.000    2.000    2.200    2.230    2.400    2.500    2.860    3.040    3.320    5.860
213 FERGUS    TP          11    0.100    0.120    0.138    0.150    0.150    0.150    0.154    0.160    0.174    0.192    0.250
```

FORMAT:20X, I10, 11F10.3

Input here is also determined by the option selected for position 12 of sub-block 3 in the MAINFILE BASICS block. Two parameters are required: the number of points in the quality probability distribution (N = 11 in this example), and the N values in the quality probability distribution arranged in ascending order. When N = 11, the values in the distribution are represented by the minimum, 10^{th} percentile, 20^{th} percentile, etc., up to the maximum value for each parameter. The number of quality distributions to be entered is defined in the previous sub-block. The distributions should be input in sets corresponding to each water quality parameter for each of the point sources. The calculation of the quality proceeds according to the method described below:

1. The model calls the random number generator which generates a random number ranging between 0 and 1.
2. The model enters the cumulative frequency distribution for solar radiation which is input by the user and selects the values from the distribution which are in the distribution positions one higher and one lower than the random number.
3. The model then employs a linear interpolation technique to calculate the exact value which corresponds to the generated random number.

ERROR CHECK: POINT SOURCE

Line 268-269	Block L8	Point Source Water Quality Probability Distribution Mapping

```
268 DISTRIBUTION Map
269                        8  6
```

FORMAT: FREE

The number 8 must appear in the column 23 of the first line of each month. The number of the month (e.g., 6 = June, 7 = July, 8= August, etc.) must appear as an integer in columns 24 to 26.

ERROR CHECK: DISTRIBUTION

Line 270-512	Block L8	Point Source Water Quality Probability Distribution Mapping

```
268 DISTRIBUTION Map
269                             8  6
270 FERGUS              DO  1  0  0  0  0  0  0  0  0  0
271 FERGUS             BOD  2  0  0  0  0  0  0  0  0  0
272 FERGUS             NOD  3  0  0  0  0  0  0  0  0  0
273 FERGUS         NO2+NO3  4  0  0  0  0  0  0  0  0  0
274 FERGUS              SS  5  0  0  0  0  0  0  0  0  0
275 FERGUS              TP  6  0  0  0  0  0  0  0  0  0
```

FORMAT: 20X, 10I3

This sub-block defines which quality probability distribution type corresponds to each flow interval for each month of the simulated portion of the year. This block must include one row for each WWTP and each parameter. The values entered refer to the specific water quality probability distribution types which were input previously in Block L7. The distribution mapping sequence of point source flow intervals must correspond to the order in which the initial point source inflows were defined. The first flow subinterval position must always be assigned a distribution type number. For Type 1, 4 or 6 calculations, there is only one flow interval and the first column above should consist of a series of numbers from 1 to the maximum number of distributions given in Block L6, e.g., 60 in this case. The remaining nine positions are either assigned distribution type numbers or set equal to 0 depending upon the calculation type (Block L4) and number of flow intervals (Block L5) specified by the user.

- Line 270 – 329 June
- Line 331 – 390 July
- Line 392 – 451 August
- Line 453 – 512 September

ERROR CHECK: N/A

Line 514	Block L10	Order of Point Source Water Quality Calculation

```
513 QUALITY ORDER OF POINT SOURCE QUALITY PARAMETERS
514                       2  1  3  4  5  6  7  8  9 10
```

FORMAT: 20X, 10I3

Specify the order in which the point source quality parameters are to be calculated in GRSM. Ten values must be entered on one line, one for each of the ten possible quality parameters. The positions along the line correspond to the 'hard-wired' order of the quality parameters. The list below describes both the hard wired order and the numeric assignment for each of the parameters.

1 = DO	5 = SS
2 = BOD	6 = TP
3 = NOD	7 = Un-ionized NH_3+
4 = NIT	8 – 10 = not presently use, however, values must be entered

The current version of the model ignores this line; the order of water quality parameters is hard-coded into the model in the following order: DO, BOD, NOD, NIT, SS, TP, Un-ionized Ammonia.

ERROR CHECK: N/A

Execution

4.4.7. BASINFLOW

BASINFLOW shows the daily average flow at each boundary inflow and the total local diffuse inflow amount to the model domain.

4.4.7.1. Template: BoundaryFlows.xls

You can use the **BoundaryFlows.xls** template to create the BASINFLOW input file. To use this template, follow the steps described below.

1. The first row contains the column headings. You can modify this information to match the names of your boundary inflow points.
2. In Column C, Day, enter the Julian day corresponding to when the data were recorded.

Julian day #152 corresponds to June 1^{st}. A Julian day calendar is available online: http://amsu.cira.colostate.edu/julian.html.

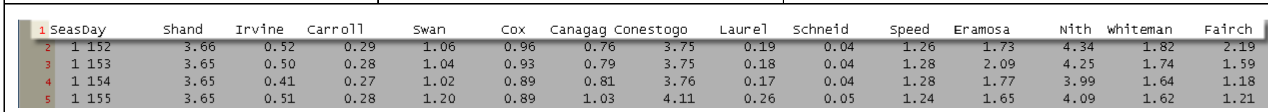
3. For each boundary inflow point, for every day of the simulation period, enter the daily average flow in m^3/s.

If you need to enter additional boundary inflow points, insert new columns to the left of the LDI column. LDI represents the total of all flows that are not explicitly entered such as small tributaries, groundwater, etc.

4. Ensure the **BoundaryFlows** worksheet is selected then click **Save As**.
5. From the **Save as type:** drop-down menu, select **Formatted Text (Space delimited) (*.prn)**.
6. Find the file on your computer and rename it with a .flo extension. The file name must be less than eight alphanumeric characters and must not include any spaces or special characters. The file must be saved in the root of your GRSM directory.

4.4.7.2. File Description

Line 1	Block --	Boundary and Local Inflows



	Seas	Day	Shand	Irvine	Carroll	Swan	Cox	Canagag	Conestogo	Laurel	Schneid	Speed	Eramosa	Nith	Whiteman	Fairch
2	1	152	3.66	0.52	0.29	1.06	0.96	0.76	3.75	0.19	0.04	1.26	1.73	4.34	1.82	2.19
3	1	153	3.65	0.50	0.28	1.04	0.93	0.79	3.75	0.18	0.04	1.28	2.09	4.25	1.74	1.59
4	1	154	3.65	0.41	0.27	1.02	0.89	0.81	3.76	0.17	0.04	1.28	1.77	3.99	1.64	1.18
5	1	155	3.65	0.51	0.28	1.20	0.89	1.03	4.11	0.26	0.05	1.24	1.65	4.09	1.62	1.21

FORMAT:

The first line of the BASINFLOW file is a dummy line used for column headings for the user's reference.

ERROR CHECK: N/A

Line 2-123	Block --	Boundary and Local Inflows

	SeasDay	Shand	Irvine	Carroll	Swan	Cox	Canagag	Conestogo	Laurel	Schneid	Speed	Eramosa	Nith	Whiteman	Fairch
2	1 152	3.66	0.52	0.29	1.06	0.96	0.76	3.75	0.19	0.04	1.26	1.73	4.34	1.82	2.19
3	1 153	3.65	0.50	0.28	1.04	0.93	0.79	3.75	0.18	0.04	1.28	2.09	4.25	1.74	1.59
4	1 154	3.65	0.41	0.27	1.02	0.89	0.81	3.76	0.17	0.04	1.28	1.77	3.99	1.64	1.18
5	1 155	3.65	0.51	0.28	1.20	0.89	1.03	4.11	0.26	0.05	1.24	1.65	4.09	1.62	1.21

FORMAT: I3,1X,I3,3X,30F10.3

Each row contains the season being simulated, the Julian day and a value for each boundary inflow in cubic metres per second. The last value in the row is the total local diffuse inflow to the model domain in cubic metres per second. There must be one row for each day of the simulation period. The maximum number of boundary inflows is 30 (including local diffuse inflow).

ERROR CHECK: N/A

4.4.8. PDFMOD

This file contains one column for each water quality parameter and one row for each boundary, each point source and each local diffuse inflow. These values allows the user to alter the probability distribution for each water quality parameter in order to simulate various point and non-point source loading scenarios. An example of PDFMOD is shown in Figure 6.

For example, to simulate a 20% reduction in TP from Conestogo River, the last value in the corresponding row would be set to -0.2. Each value in the probability distribution for TP for Conestogo River will then be multiplied by 0.8 (i.e., 1 – 0.2). The default value is 0, which means the probability distributions are not modified.

Figure 6: Example of PDFMOD

1	SOURCE	DO	BOD	NOD	NIT	SS	TP
2	SHAND DAM	0.00	0.00	0.00	0.00	0.00	0.00
3	IRVINE CK	0.00	0.00	0.00	0.00	0.00	0.00
4	CARROLL CK	0.00	0.00	0.00	0.00	0.00	0.00
5	SWAN CREEK	0.00	0.00	0.00	0.00	0.00	0.00
6	COX CREEK	0.00	0.00	0.00	0.00	0.00	0.00
7	CANGAGIGUE	0.00	0.00	0.00	0.00	0.00	0.00

4.4.9. STP_FLOW_FILE

STP_FLOW_FILE shows the daily flow time series for each WWTP. The input source of the WWTP inflow data are determined by position 3 on line 5 of the BASICS block in MAINFILE. If the switch is set to 0, the data are calculated internally using the coefficients in the STPFLOW file (see 4.4.6). If the switch is set to 1, the WWTP flow data are read from this file.

4.4.9.1. Template: WWTP_Flows.xls

You can use the **WWTP_Flows.xls** template to create the STP_FLOW_FILE input file. To use this template, follow the steps described below.

1. The first row is a comment field that you can modify as required.
2. The second row contains the names of the WWTPs. You can modify these names, as long as they are less than 10 characters in length.
3. In Column C, Day, enter the Julian day corresponding to when the data were recorded.

Julian day #152 corresponds to June 1st. A Julian day calendar is available online: http://amsu.cira.colostate.edu/julian.html.

4. The third row contains a scaling factor that is multiplied by each flow value in the time series. This is a convenient way to run different scenarios looking at higher or lower WWTP flows by increasing or decreasing the scaling factor.

To run a scenario where the effluent flow from Guelph would increase by 50%, change the scaling factor for Guelph to 1.5.

5. For each WWTP, for every day of the simulation period, enter the daily average flow in m^3/s.
6. Ensure the **WWTP_Flows** worksheet is selected then click **Save As**.
7. From the **Save as type:** drop-down menu, select **Formatted Text (Space delimited) (*.prn)**.
8. Find the file on your computer and rename it with a .flo extension. The file name must be less than eight alphanumeric characters and must not include any spaces or special characters. The file must be saved in the root of your GRSM directory.

4.4.9.2. File Description

Line 1-2	Block --	WWTP FLOW

```
1 Free format file containing daily STP flows (cms) for each point source
2 SeasDay      Fergus     Elora  Waterloo Kitchener   Guelph  Hespeler   Preston      Galt     Paris Brantford
3                 1.0       1.0       1.0       1.0      1.0       1.0       1.0       1.0       1.0       1.0
4   1 152       0.043     0.017     0.476     0.833    0.597     0.073     0.132     0.475     0.039     0.485
5   1 153       0.043     0.017     0.447     0.787    0.525     0.095     0.130     0.372     0.039     0.485
```

FORMAT: --

These are dummy lines that will not be read by the GRSM and are included as column headings for the user's reference.

ERROR CHECK: N/A

Execution

Line 3	Block --	WWTP FLOW

```
1 Free format file containing daily STP flows (cms) for each point source
2 SeasDay      Fergus     Elora  Waterloo Kitchener    Guelph  Hespeler   Preston      Galt     Paris Brantford
3                 1.0       1.0       1.0       1.0       1.0       1.0       1.0       1.0       1.0       1.0
4   1 152       0.043     0.017     0.476     0.833     0.597     0.073     0.132     0.475     0.039     0.485
5   1 153       0.043     0.017     0.447     0.787     0.525     0.095     0.130     0.372     0.039     0.485
```

FORMAT: --

The third line is a scaling factor that can be used to change the WWTP flow value in order to examine the impact of changing the hydraulic capacity of the WWTP. The default value is 1.0, which does not affect the WWTP flow values. For example, to run a scenario where the effluent flow from Guelph would increase by 50%, change the scaling factor for Guelph to 1.5.

ERROR CHECK: N/A

Line 4-125	Block --	WWTP FLOW

```
1 Free format file containing daily STP flows (cms) for each point source
2 SeasDay      Fergus     Elora  Waterloo Kitchener    Guelph  Hespeler   Preston      Galt     Paris Brantford
3                 1.0       1.0       1.0       1.0       1.0       1.0       1.0       1.0       1.0       1.0
4   1 152       0.043     0.017     0.476     0.833     0.597     0.073     0.132     0.475     0.039     0.485
5   1 153       0.043     0.017     0.447     0.787     0.525     0.095     0.130     0.372     0.039     0.485
```

FORMAT: I3, 1X, I3, 3X, 10F10.3

Each row contains the season being simulated, the Julian day and a value for each WWTP inflow in cubic metres per second. The input file must contain one row for each day of the simulation period.

ERROR CHECK: N/A

4.4.10. STORM

STORM shows the flow and quality data for an urban catchment. The GRSM requires one STORM file for each urban inflow included in the model, which is specified by the NSTOFL value in the BASICS block of MAINFILE. The format of the data in each STORM file is described below.

4.4.10.1. File Description

Line 1 – 1464	Block ---	URBAN FLOW AND QUALITY

```
  1 152  1      0.550      9.100      0.206      1.474      0.248      3.750      0.010
  1 152  2      0.550      9.100      0.206      1.474      0.248      3.750      0.010
  1 152  3      0.550      9.100      0.206      1.474      0.248      3.750      0.010
  1 152  4      0.539      9.100      0.206      1.474      0.248      3.750      0.010
  1 152  5      0.539      9.100      0.206      1.474      0.248      3.750      0.010
  1 152  6      0.539      9.100      0.206      1.474      0.248      3.750      0.010
  1 152  7      0.539      9.100      0.206      1.474      0.248      3.750      0.010
```

FORMAT: I3, 1X, I3, 1X, I2, 10F10.3

If the urban point source (stormwater) inputs are to be included in the simulation, the user must create one STORM file for every urban catchment included in the simulation (up to a maximum of 30). Once the STORM files have been created, be sure to update units 70 to 79 (if applicable) of FILENAME.DAT. The data contained in each row are as follows:

1. Year
2. Julian day
3. Time step
4. Flow (in cubic metres per second, m^3/s)
5. Quality parameters:
   - DO
   - BOD
   - NOD
   - NIT
   - SS
   - TP

Storm flows can be estimated using a variety of hydrologic models such as GAWSER, HSPF, SWMM, etc. These models can also be used to get an estimate of the suspended sediment concentration and other water quality parameters. Some approaches that have been used to estimate quantity and quality of urban runoff can be found in Stantec (2009) and CH2M Gore and Storrie (1996).

ERROR CHECK: N/A

4.4.11. METDATA

METDATA contains daily values of solar radiation and water temperature data required by the GRSM.

4.4.11.1. Template: WaterTemp.xls

You can use the **WaterTemp.xls** template to create the METDATA input file. When you open this template, you will see more than one worksheet where data can be entered. The template was set up this way due to limitations in the number of columns that can be exported from MS Excel to a text file. If you have more than 22 reaches in your simulation, you will have to enter your data in more than one worksheet and use the executable file **MakeMet.exe**. Start by entering data in the **WaterTemp1** worksheet and following the steps described below.

1. The first row contains the column headings and should not be modified.
2. In Column C, enter the Julian day corresponding to when the data were recorded. You will have to enter 12 rows for each day as you need to enter data for every 2 hour timestep in one day.

Julian day #152 corresponds to June 1st. A Julian day calendar is available online: http://amsu.cira.colostate.edu/julian.html.

3. In Column D, enter the time step number (consecutive, starting at 1 and ending at 12).
4. In Column E, Solar, enter the daily total radiation in Langleys for each timestep of the simulation.

You can use the same value for each time step on the same day, as the GRSM will apply a half sine factor to simulate changes in solar radiation throughout the day.

5. Enter the water temperature (ºCelsius) for each reach for every 2 hour timestep of the simulation. Use measured data if they are available. Otherwise, enter simulated or estimated water temperature data.

If you have more than 22 reaches in your simulation, use (and create, if necessary) additional worksheets. For example, you should use:

- **WaterTemp2** for reaches 23 to 46
- **WaterTemp3** for reaches 47 to 70
- **WaterTemp4** for reaches 71 to 94
- **WaterTemp5** for reaches 95 to 100

6. Save each worksheet as a **Formatted Text (Space delimited) (*.prn)** file. The file name must be **less than eight alphanumeric characters** and must not include any spaces or special characters.
   - If you have 22 reaches or less, jump to step 9.
   - If you have more than 22 reaches, save the PRN files in the same folder as **MakeMet.exe** and proceed to step 7.
7. Double-click **MakeMet.exe** and follow the prompts in the DOS window.
   - Enter the number of PRN files (up to five).
   - Type the name of the first PRN file, including the file extension (.prn).
   - Type the name of the subsequent PRN files, pressing ENTER after each.
8. A new file, **temp.met**, will be created in the same folder as **MakeMet.exe**.
9. Copy the file to the root of your GRSM directory and ensure it has a **.met** extension. The file name must be less than eight alphanumeric characters and must not include any spaces or special characters.

4.4.11.2. File Description

Line 1	Block ---	SOLAR RADIATION AND WATER TEMPERATURE

```
 9              Solar    Reach 1   Reach 2   Reach 3   Reach 4   Reach 5   Reach 6
 1 152   1    383.250      9.430    13.600    14.550    15.500    16.450    17.400
 1 152   2    383.250      9.470    12.860    13.730    14.610    15.480    16.350
 1 152   3    383.250      9.280    12.120    13.070    14.010    14.960    15.910
 1 152   4    383.250      9.530    11.530    12.580    13.620    14.670    15.710
 1 152   5    383.250     10.340    12.260    13.250    14.240    15.230    16.220
 1 152   6    383.250     11.110    12.120    13.200    14.280    15.360    16.440
```

FORMAT: FREE

The first line of this file must contain the number 9 in column 3. The rest of the first line is a dummy line that contains column headings for the user's reference.

ERROR CHECK:

Line 2 - 1465	Block ---	SOLAR RADIATION AND WATER TEMPERATURE

1	9			Solar	Reach 1	Reach 2	Reach 3	Reach 4	Reach 5	Reach 6
2	1	152	1	383.250	9.430	13.600	14.550	15.500	16.450	17.400
3	1	152	2	383.250	9.470	12.860	13.730	14.610	15.480	16.350
4	1	152	3	383.250	9.280	12.120	13.070	14.010	14.960	15.910
5	1	152	4	383.250	9.530	11.530	12.580	13.620	14.670	15.710
6	1	152	5	383.250	10.340	12.260	13.250	14.240	15.230	16.220
7	1	152	6	383.250	11.110	12.120	13.200	14.280	15.360	16.440

FORMAT: I3, 1X, I3, 3X, F10.3, 28F10.3

It has been determined that the model is very sensitive to water temperature and that the subroutines which estimate water temperature in GRSM are not sufficiently accurate. Accordingly, observed water temperature is used as input as much as possible and the data are interpolated for the reaches between two adjacent real-time water quality stations. Each row of the input file contains the season of the simulation, the Julian day, timestep number, total daily solar radiation in Langleys and water temperature for each reach, up to a maximum of 100 reaches. The total daily solar radiation is input for each timestep, the model distributes this value over the daylight period based on a half-sine curve using the coefficients specified in Blocks N1 and O1 of RATEFILE.

ERROR CHECK: N/A

4.5. Output Files

Once a GRSM execution is complete, 26 new files are created in **C:\GRSM**. GRSM.OUT echoes the data entered in the input files. The remaining 25 files fall in one of two file types: temporary or data. The sections that follow provide additional information regarding each file type.

To confirm that the data entered in the input files are accurate, consider opening the GRSM.OUT file in a text editor and reviewing the data.

4.5.1. Temporary Files

A number of temporary or intermediate files are created during a GRSM execution. These files are used to transfer information between subroutines in GRSM and can be used to verify that data are being input correctly. Each subroutine uses some of the input data to generate a time series of the routine data. These subroutines are controlled by True/False flags in the BYPASS.DAT file.

Table 3 describes the content of each temporary file. **Note: these files can be deleted after an execution.**

Table 3: Description of temporary files

File Name	Description
TEMP8	PDF map for WWTP quality
TEMP9	PDF map for boundary quality
RUN1.10	Boundary flows in cubic feet per second. The boundary flows are exported to the temporary file in the order that they were input to the model.
RUN1.12	Independent flows. This is equal to the number of boundary flows, if no minimum regulation policy is specified in Block K2 of FLOWFILE) in cubic feet per second.
RUN1.13	WWTP flows in cubic feet per second. The WWTP flows are exported in a matrix for each day of the simulation containing rows with the effluent flow from each WWTP for each timestep.
RUN1.14	Local diffuse inflows to each reach in cubic feet per second. The order of local diffuse inflows is specified in sub-block F6 of MAINFILE.

File Name	Description
RUN1.15	Estimated flow in cubic feet per second at the head and end of each reach for each timestep of each day of the simulation.
RUN1.16	Average daily flow, water depth and channel velocity for each reach on each day of the simulation. This file also contains the channel velocity for each reach for each timestep for each day of the simulation.
RUN1.17	Urban stormwater flows in cubic feet per second for each timestep of each day of the simulation.
RUN1.18	Reproduces the METDATA file, including the sunlight intensity factor in the 5th column.
RUN1.20	Stream rate parameters for each reach at each timestep on each day of the simulation. Each row contains the reach number, timestep, photosynthesis rate*, sediment oxygen demand rate, respiration rate*, reaeration rate, NOD decay rate, BOD removal rate, BOD deoxygenation rate, DO saturation concentration (mg/L), ammonia volatilization rate and denitrification rate. **only used if ECOL is turned off*
RUN1.21	Quality of boundary flows for each timestep on each day of the simulation. IQP 1 = DO IQP 2 = BOD IQP 3 = NOD IQP 4 = NO3 IQP 5 = TSS IQP 6 = TP
RUN1.22	WWTP effluent quality for each timestep on each day of the simulation. See RUN1.21 for IQP values.
RUN1.23	Local diffuse inflow quality for each timestep on each day of the simulation. See RUN1.21 for IQP values.
RUN1.24	Daily distribution factors for total solar radiation for each timestep in each month of the simulation. Read from the METDATA file and distributed over each timestep based on the sunrise time, day length and incident angle of sunlight.
RUN1.27	Urban stormwater quality for each timestep on each day of the simulation.

The GRSM reads the temporary files listed in Table 3 and models all the processes affecting the concentration of each water quality parameter, calling the ECOL subroutine if necessary. The output is sent to the four files described in Table 4. This consolidation of data allows the GRSM to analyse the data more easily.

Execution

Table 4: Description of consolidated temporary files

File Name	Variables	Description
RUN1.25	DO, Temperature	Dissolved oxygen and temperature for each reach at each timestep on each day of the simulation. Ignore the first column. Subsequent columns represent each reach, two rows per timestep on each day. The first of the two rows is the dissolved oxygen (mg/L) and the second is the water temperature in ºC.
RUN1.50	BOD, NOD, NIT, SS, TP, UIA	Water quality output for each reach at each timestep on each day of the simulation. Ignore the first column. Subsequent columns represent each reach, six rows per timestep on each day. Row 1 is BOD concentration (mg/L). Row 2 is NOD (mg/L). Row 3 is NO3 (mg/L). Row 4 is TSS (mg/L). Row 5 is TP (mg/L). Row 6 is un-ionized ammonia (mg/L).
RUN1.54	CLAD, POT, MIL, DO2UP, DO2P, PINP	Output from ECOL subroutine for each reach at each timestep on each day of the simulation. Ignore the first column. Subsequent columns represent each reach, six rows per timestep on each day. Row 1 is Cladophora concentration (g/m^2). Row 2 is Potamogeton concentration (g/m^2). Row 3 is Milfoil concentration (g/m^2). Row 4 is the oxygen taken up during biomass respiration (mg/L). Row 5 is oxygen produced by biomass photosynthesis (mg/L). Row 6 is phosphorus concentration in plant tissue (g P/g biomass).
RUN1.55	O2UP, O2P, TRES, TPROD	Output from ECOL subroutine for each reach at each timestep on each day of the simulation. Ignore the first column. Subsequent columns represent each reach, four rows per timestep on each day. Row 1 is the biomass respiration rate (g DO/m^2). Row 2 is biomass photosynthesis rate (g DO/m^2). Row 3 is biomass respiration rate (g $biomass/m^2$). Row 4 is the biomass photosynthesis rate (g $biomass/m^2$).

4.5.2. Data Files

The data files are created in comma-separated value (CSV) format based on the output files described in Table 4. Files of this format can be opened with a spreadsheet application, such as Microsoft Office Excel. Advanced knowledge of spreadsheet applications is recommended to extract the most information from the output data files.

Each data file follows the same file name format, **YYYY_##a.csv**, where:

- **YYYY** is the year of the execution entered in the input files
- **##** is the execution number entered in the input files and is a number between 1 and 99
- **a** specifies the data file and is either **hyd**, **b**, **e**, **s**, or **w** (see Table 5 for additional information)

Table 5 provides a brief description of each output data file as well as a list of variables that are included in each file. For a complete list of variables included in the output data files, as well as a definition of each variable, refer to **Appendix D: Output Files Variables**.

Table 5: Description of data files

File Name	Description	Variables
2007_1_hyd.csv	Hydrological data Note: 12 rows are identical as this data represents a daily average	Day, Time, Date, Reach flow, Depth, Vel (velocity)
2007_1b.csv	Activity of aquatic plants, including changes in biomass, photosynthetic oxygen production, and respiratory oxygen intake	Run, Day, Time, Date, Reach, CLAD, POT, MIL, PINP, DO2UP, DO2P, O2UP, O2P, TRES, TPROD
2007_1e.csv	Aquatic plant growth	Run, Day, Time, Date, Reach, eCLAD, ePOT, eEPI, o2last, pard, pinp, fpin, ctfp, ptfp, etfp, ctfr, ptfr, etfr, radc, radp, rade, cladp, potp, epip, cladw, potw, epiw, wati, depth, ke, kw, eTEMP, psuply, totp, nsuply, totn, pfac
2007_1s.csv	Variation of the oxygen equation components	Day, Time, Reach, Iratc, Date, xCS, xDO, xBOD, xNOD, xPROD, xRESP, xSLU
2007_1w.csv	Water quality	Run, Day, Time, Date, Reach, BOD, NOD, NIT, SS, TP, UIA, DO, Temp

5. Calibration and Validation

The process of model **calibration** requires the adjustment of certain model parameters within reasonable ranges so that the simulation results and the observed data are in close agreement. The process of model **verification**, which can be referred to as a validation of the calibrated model, requires the comparison of another independent set of observed data with the results of a simulation set up to model the second set of conditions.

If the simulation results for the verification execution are satisfactory (i.e., in close agreement with the observed data), the processes of model calibration and verification are said to be complete and the model is suitable for application. However, if the observed data are not reproduced by the model within acceptable limits during the process of verification, a further refinement of the model calibration must be performed. This is achieved by further adjusting the most sensitive model parameters, as defined by a sensitivity analysis, and then repeating the calibration and verification executions and analysis. This refinement process is repeated until both the calibration and verification executions achieve satisfactory results.

The GRSM has been calibrated and validated with four years of recent data, representing a range of flow and climate conditions. Numerous parameters and rate coefficients require calibration. However, calibration is typically achieved by adjusting reaeration rate constants, initial aquatic plant biomass and biomass inhibition coefficients.

Additional guidance to calibrate and validate the GRSM is provided in the GRSM Technical Guidance Document, available under separate cover.

6. Troubleshooting

As discussed in this User Manual, the GRSM has built-in error checking mechanisms in place. You will encounter two basic types of errors during an execution of the GRSM:

1. If the GRSM encounters unexpected data in a built-in error check, it will stop and give an error message. This error message will typically include a line number so you can verify the data entered in the input files.
2. If the GRSM encounters unexpected data where there is no built-in error check, it will stop without providing an error message or a line number. These types of errors are hard to fix.

A list of common error messages is included in the sections that follow, along with a solution to fix the problem.

6.1. Error Message #1

Error opening filename = *[input file name]*

This error indicates that GRSM cannot find one of the files in the FILENAME.DAT file. Check FILENAME.DAT file to confirm that all input files exist in the correct folder and the filenames are spelled correctly.

6.2. Error Message #2

The value of the STATUS specifier in an OPEN statement does not match the file status (unit = *n*).

This error indicates that GRSM cannot open one of the files in the FILENAME.DAT file. Verify and confirm that all of the input files are not in use by another program and FILENAME.DAT conforms to the format given in section 4.4. The unit number *n* in the error message corresponds to the unit number given in FILENAME.DAT.

6.3. Error Message #3

INVALID CODE = *[what the model read from the input file]* – EXPECTED CODE = *[text of error check that the model was expecting]*

This error indicates that one of the input files contains more or less rows than expected and subsequently the model is not reading the correct error check text. The error message will tell the user what text was read and what was expected, which will assist in determining where the error occurred and in which file.

An error of this type will likely generate multiple error messages. Start by troubleshooting the first error. Once it has been rectified, most of the subsequent errors should be fixed as well.

6.4. Error Message #4

ERROR IN *[input file]* – READ *[what the model read from the input file]* – EXPECTED *[text of error check that the model was expecting to read]*

See 6.3 Error Message #3.

6.5. Error Message #5

Invalid decimal character *R* was detected (unit = *n*)

This error occurs when the model is expecting a decimal number but the position contains a text character. The unit number *n* in the error message corresponds to the unit number given in FILENAME.DAT where the error occurs.

7. References

Anderson, Mark. Personal interview. May 6th, 2010.

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Heathcote, Isobel W. 2009. *Review and Comparison of Dissolved Oxygen Models Appropriate for the Grand River Watershed*. Wyndham Research Inc. January.

Stantec Consulting Ltd. 2009. *Kitchener WWTP Assimilative Capacity Assessment, Phase II, Technical Memorandum 3 Tool Development*. Report prepared for the Regional Municipality of Waterloo. December.

Appendix A: Worked Example

Appendix A: Worked Example

Appendix A: Worked Example

The following document describes how to modify the example input files to perform the following tasks:

1. Add a new boundary inflow (i.e., tributary) to GRSM
2. Add a new WWTP to GRSM
3. Modify the effluent flow from the new WWTP to reflect a scenario showing future growth
4. Modify the effluent quality from the new WWTP to reflect a scenario showing future upgrades

How to Add a New Boundary to GRSM

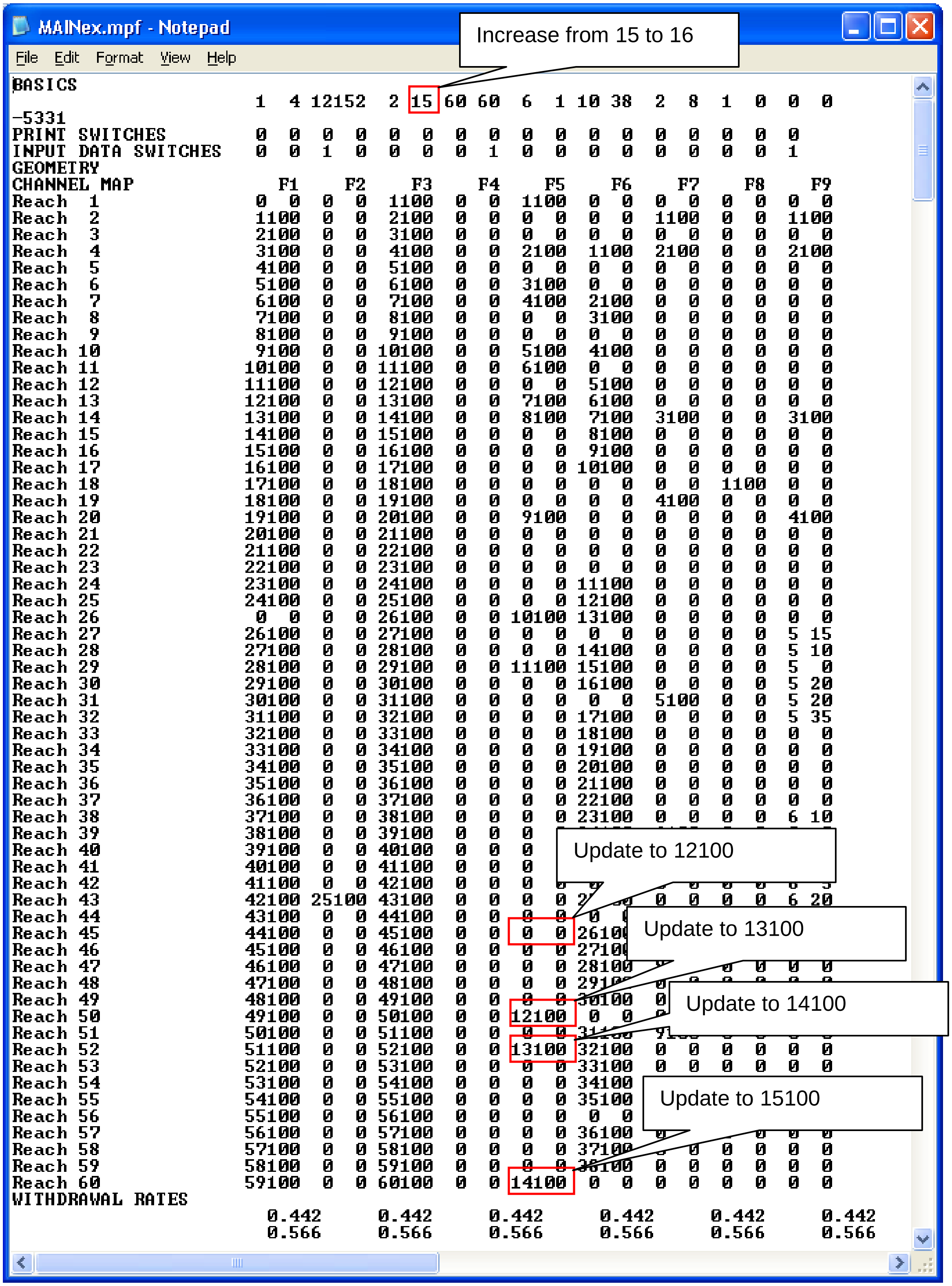
To add a new boundary to GRSM, the following information is required:

- Daily average flow for each day of the simulation period based on flow monitoring (or another estimate such as a hydrologic model).
- Water quality data to describe the probability distributions for DO, BOD, NOD, NO3, TSS and TP for this tributary based on measured water quality or some other estimate.
- The model reach that the tributary enters into.

The example input files are set up for a model domain containing 60 reaches and 15 boundary inflows (i.e., 14 tributaries and local diffuse inflow). The following section describes the steps required to add a new boundary called Smith Creek to the model. This new boundary will enter the model domain at Reach 45.

Step 1: Modify MAINFILE

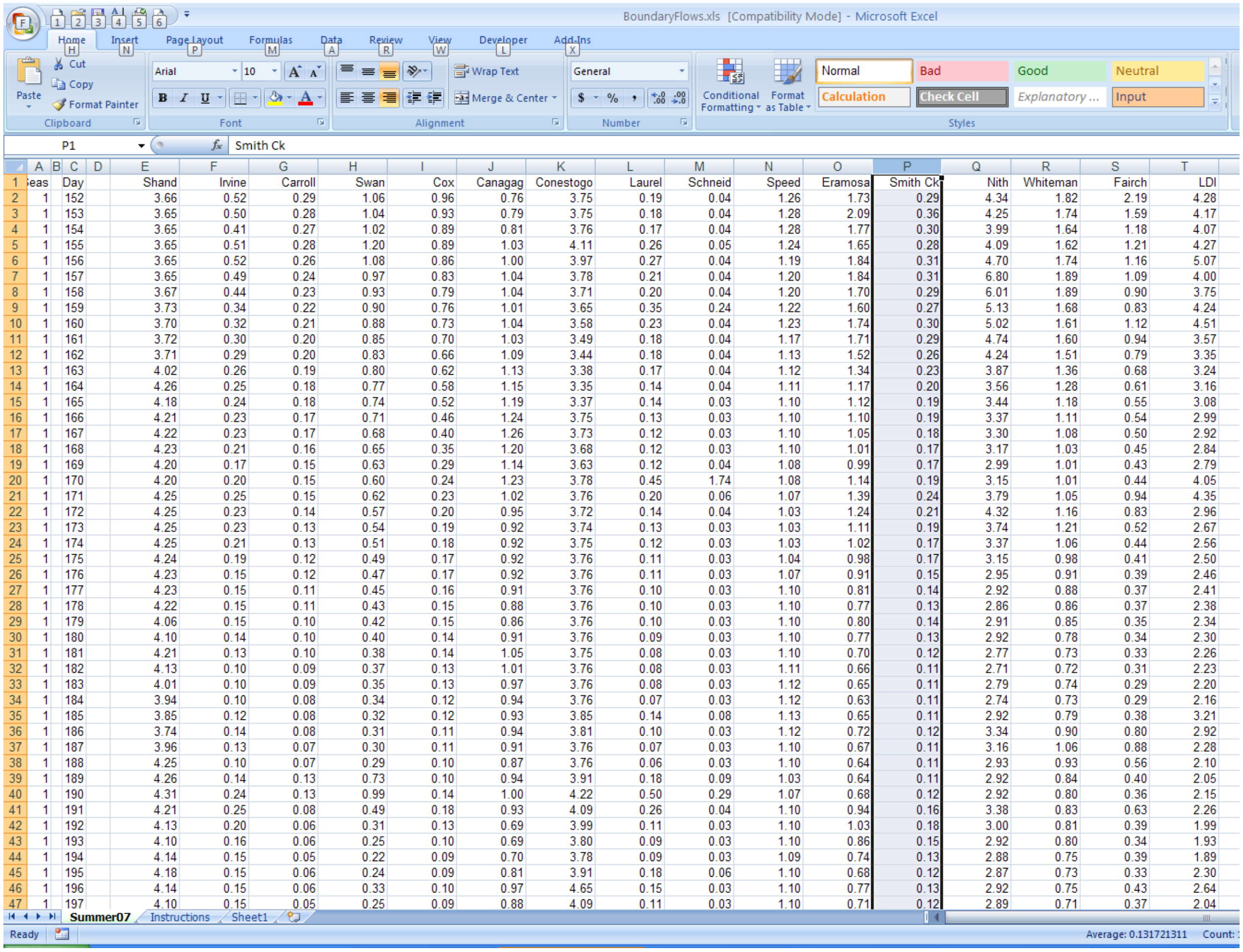
Increase the number of boundary inflows in the BASICS block of MAINFILE and update the GEOMETRY block to show this new inflow to Reach 45. The following screen shots highlight the sections of MAINFILE that need to be updated to include Smith Creek. Note that all subsequent boundary flows in the GEOMETRY block need to be renumbered to maintain the sequential order of the boundary inflows and to account for the fact that Smith Creek is now boundary #12 (e.g., the inflow 12 becomes inflow 13).




```
BASICS
                         1   4 12152   2  15  60  60   6   1  10  38   2   8   1   0   0   0
-5331
PRINT SWITCHES           0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
INPUT DATA SWITCHES      0   0   1   0   0   0   0   1   0   0   0   0   0   0   0   0   1
GEOMETRY
CHANNEL MAP                F1      F2      F3      F4      F5      F6      F7      F8      F9
Reach  1                 0   0   0   0  1100   0   0  1100   0   0   0   0   0   0   0   0
Reach  2              1100   0   0  2100   0   0   0   0   0   0  1100   0   0  1100
Reach  3              2100   0   0  3100   0   0   0   0   0   0   0   0   0   0   0   0
Reach  4              3100   0   0  4100   0   0  2100  1100  2100   0   0  2100
Reach  5              4100   0   0  5100   0   0   0   0   0   0   0   0   0   0   0   0
Reach  6              5100   0   0  6100   0   0  3100   0   0   0   0   0   0   0   0
Reach  7              6100   0   0  7100   0   0  4100  2100   0   0   0   0   0   0
Reach  8              7100   0   0  8100   0   0   0   0  3100   0   0   0   0   0   0
Reach  9              8100   0   0  9100   0   0   0   0   0   0   0   0   0   0   0   0
Reach 10              9100   0   0 10100   0   0  5100  4100   0   0   0   0   0   0
Reach 11             10100   0   0 11100   0   0  6100   0   0   0   0   0   0   0   0
Reach 12             11100   0   0 12100   0   0   0   0  5100   0   0   0   0   0   0
Reach 13             12100   0   0 13100   0   0  7100  6100   0   0   0   0   0   0
Reach 14             13100   0   0 14100   0   0  8100  7100  3100   0   0  3100
Reach 15             14100   0   0 15100   0   0   0   0  8100   0   0   0   0   0   0
Reach 16             15100   0   0 16100   0   0   0   0  9100   0   0   0   0   0   0
Reach 17             16100   0   0 17100   0   0   0   0 10100   0   0   0   0   0   0
Reach 18             17100   0   0 18100   0   0   0   0   0   0   0   0  1100   0   0
Reach 19             18100   0   0 19100   0   0   0   0   0   0  4100   0   0   0   0
Reach 20             19100   0   0 20100   0   0  9100   0   0   0   0   0   0  4100
Reach 21             20100   0   0 21100   0   0   0   0   0   0   0   0   0   0   0   0
Reach 22             21100   0   0 22100   0   0   0   0   0   0   0   0   0   0   0   0
Reach 23             22100   0   0 23100   0   0   0   0   0   0   0   0   0   0   0   0
Reach 24             23100   0   0 24100   0   0   0   0 11100   0   0   0   0   0   0
Reach 25             24100   0   0 25100   0   0   0   0 12100   0   0   0   0   0   0
Reach 26                 0   0   0   0 26100   0   0 10100 13100   0   0   0   0   0   0
Reach 27             26100   0   0 27100   0   0   0   0   0   0   0   0   0   0   5  15
Reach 28             27100   0   0 28100   0   0   0   0 14100   0   0   0   0   5  10
Reach 29             28100   0   0 29100   0   0 11100 15100   0   0   0   0   5   0
Reach 30             29100   0   0 30100   0   0   0   0 16100   0   0   0   0   5  20
Reach 31             30100   0   0 31100   0   0   0   0   0   0  5100   0   0   5  20
Reach 32             31100   0   0 32100   0   0   0   0 17100   0   0   0   0   5  35
Reach 33             32100   0   0 33100   0   0   0   0 18100   0   0   0   0   0   0
Reach 34             33100   0   0 34100   0   0   0   0 19100   0   0   0   0   0   0
Reach 35             34100   0   0 35100   0   0   0   0 20100   0   0   0   0   0   0
Reach 36             35100   0   0 36100   0   0   0   0 21100   0   0   0   0   0   0
Reach 37             36100   0   0 37100   0   0   0   0 22100   0   0   0   0   0   0
Reach 38             37100   0   0 38100   0   0   0   0 23100   0   0   0   0   6  10
Reach 39             38100   0   0 39100   0   0   0 [illegible]
Reach 40             39100   0   0 40100   0   0   0 [illegible]
Reach 41             40100   0   0 41100   0   0   0 [illegible]
Reach 42             41100   0   0 42100   0   0   0 [illegible]
Reach 43             42100 25100 43100   0   0   0   0 [illegible]   0   0   0   0   6  20
Reach 44             43100   0   0 44100   0   0   0   0   0 [illegible]
Reach 45             44100   0   0 45100   0   0   0   0 [illegible]
Reach 46             45100   0   0 46100   0   0   0   0 [illegible]
Reach 47             46100   0   0 47100   0   0   0   0 28100 [illegible]   0   0   0   0
Reach 48             47100   0   0 48100   0   0   0   0 [illegible]
Reach 49             48100   0   0 49100   0   0   0   0 30100   0 [illegible]
Reach 50             49100   0   0 50100   0   0 12100   0   0 [illegible]
Reach 51             50100   0   0 51100   0   0   0   0 [illegible]
Reach 52             51100   0   0 52100   0   0 13100 32100   0   0   0   0   0   0
Reach 53             52100   0   0 53100   0   0   0   0 33100   0   0   0   0   0   0
Reach 54             53100   0   0 54100   0   0   0   0 34100 [illegible]
Reach 55             54100   0   0 55100   0   0   0   0 35100 [illegible]
Reach 56             55100   0   0 56100   0   0   0   0   0   0 [illegible]
Reach 57             56100   0   0 57100   0   0   0   0 36100 [illegible]   0   0   0
Reach 58             57100   0   0 58100   0   0   0   0 [illegible]   0   0   0   0   0
Reach 59             58100   0   0 59100   0   0   0   0 [illegible]   0   0   0   0   0   0
Reach 60             59100   0   0 60100   0   0 14100   0   0   0   0   0   0   0   0
WITHDRAWAL RATES
                           0.442       0.442       0.442       0.442       0.442       0.442
                           0.566       0.566       0.566       0.566       0.566       0.566
```

Step 2: Modify BASINFLOW

Update the BASINFLOW file to include daily average flows in cubic metres per second for Smith Creek for each day of the simulation. For this example, the BoundaryFlow.xls template was used to update BASINFLOW to include flows for Smith Creek. The screen capture below shows the flow data for Smith Creek being inserted into the template as the new 12th boundary inflow.

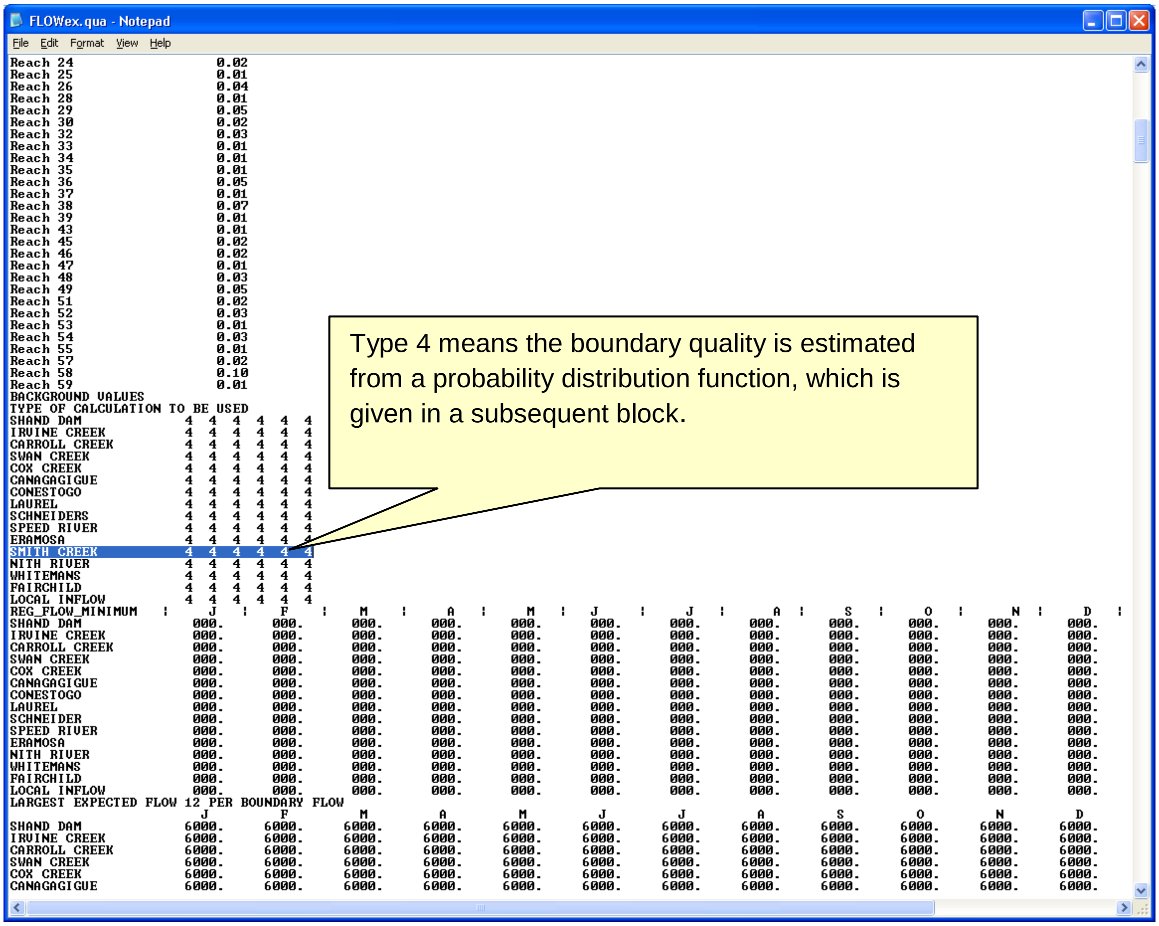


Seas	Day	Shand	Irvine	Carroll	Swan	Cox	Canagag	Conestogo	Laurel	Schneid	Speed	Eramosa	Smith Ck	Nith	Whiteman	Fairch	LDI
1	152	3.66	0.52	0.29	1.06	0.96	0.76	3.75	0.19	0.04	1.26	1.73	0.29	4.34	1.82	2.19	4.28
1	153	3.65	0.50	0.28	1.04	0.93	0.79	3.75	0.18	0.04	1.28	2.09	0.36	4.25	1.74	1.59	4.17
1	154	3.65	0.41	0.27	1.02	0.89	0.81	3.76	0.17	0.04	1.28	1.77	0.30	3.99	1.64	1.18	4.07
1	155	3.65	0.51	0.28	1.20	0.89	1.03	4.11	0.26	0.05	1.24	1.65	0.28	4.09	1.62	1.21	4.27
1	156	3.65	0.52	0.26	1.08	0.86	1.00	3.97	0.27	0.04	1.19	1.84	0.31	4.70	1.74	1.16	5.07
1	157	3.65	0.49	0.24	0.97	0.83	1.04	3.78	0.21	0.04	1.20	1.84	0.31	6.80	1.89	1.09	4.00
1	158	3.67	0.44	0.23	0.93	0.79	1.04	3.71	0.20	0.04	1.20	1.70	0.29	6.01	1.89	0.90	3.75
1	159	3.73	0.34	0.22	0.90	0.76	1.01	3.65	0.35	0.24	1.22	1.60	0.27	5.13	1.68	0.83	4.24
1	160	3.70	0.32	0.21	0.88	0.73	1.04	3.58	0.23	0.04	1.23	1.74	0.30	5.02	1.61	1.12	4.51
1	161	3.72	0.30	0.20	0.85	0.70	1.03	3.49	0.18	0.04	1.17	1.71	0.29	4.74	1.60	0.94	3.57
1	162	3.71	0.29	0.20	0.83	0.66	1.09	3.44	0.18	0.04	1.13	1.52	0.26	4.24	1.51	0.79	3.35
1	163	4.02	0.26	0.19	0.80	0.62	1.13	3.38	0.17	0.04	1.12	1.34	0.23	3.87	1.36	0.68	3.24
1	164	4.26	0.25	0.18	0.77	0.58	1.15	3.35	0.14	0.04	1.11	1.17	0.20	3.56	1.28	0.61	3.16
1	165	4.18	0.24	0.18	0.74	0.52	1.19	3.37	0.14	0.03	1.10	1.12	0.19	3.44	1.18	0.55	3.08
1	166	4.21	0.23	0.17	0.71	0.46	1.24	3.75	0.13	0.03	1.10	1.10	0.19	3.37	1.11	0.54	2.99
1	167	4.22	0.23	0.17	0.68	0.40	1.26	3.73	0.12	0.03	1.10	1.05	0.18	3.30	1.08	0.50	2.92
1	168	4.23	0.21	0.16	0.65	0.35	1.20	3.68	0.12	0.03	1.10	1.01	0.17	3.17	1.03	0.45	2.84
1	169	4.20	0.17	0.15	0.63	0.29	1.14	3.63	0.12	0.04	1.08	0.99	0.17	2.99	1.01	0.43	2.79
1	170	4.20	0.20	0.15	0.60	0.24	1.23	3.78	0.45	1.74	1.08	1.14	0.19	3.15	1.01	0.44	4.05
1	171	4.25	0.25	0.15	0.62	0.23	1.02	3.76	0.20	0.06	1.07	1.39	0.24	3.79	1.05	0.94	4.35
1	172	4.25	0.23	0.14	0.57	0.20	0.95	3.72	0.14	0.04	1.03	1.24	0.21	4.32	1.16	0.83	2.96
1	173	4.25	0.23	0.13	0.54	0.19	0.92	3.74	0.13	0.03	1.03	1.11	0.19	3.74	1.21	0.52	2.67
1	174	4.25	0.21	0.13	0.51	0.18	0.92	3.75	0.12	0.03	1.03	1.02	0.17	3.37	1.06	0.44	2.56
1	175	4.24	0.19	0.12	0.49	0.17	0.92	3.76	0.11	0.03	1.04	0.98	0.17	3.15	0.98	0.41	2.50
1	176	4.23	0.15	0.12	0.47	0.17	0.92	3.76	0.11	0.03	1.07	0.91	0.15	2.95	0.91	0.39	2.46
1	177	4.23	0.15	0.11	0.45	0.16	0.91	3.76	0.10	0.03	1.10	0.81	0.14	2.92	0.88	0.37	2.41
1	178	4.22	0.15	0.11	0.43	0.15	0.88	3.76	0.10	0.03	1.10	0.77	0.13	2.86	0.86	0.37	2.38
1	179	4.06	0.15	0.10	0.42	0.15	0.86	3.76	0.10	0.03	1.10	0.80	0.14	2.91	0.85	0.35	2.34
1	180	4.10	0.14	0.10	0.40	0.14	0.91	3.76	0.09	0.03	1.10	0.77	0.13	2.92	0.78	0.34	2.30
1	181	4.21	0.13	0.10	0.38	0.14	1.05	3.75	0.08	0.03	1.10	0.70	0.12	2.77	0.73	0.33	2.26
1	182	4.13	0.10	0.09	0.37	0.13	1.01	3.76	0.08	0.03	1.11	0.66	0.11	2.71	0.72	0.31	2.23
1	183	4.01	0.10	0.09	0.35	0.13	0.97	3.76	0.08	0.03	1.12	0.65	0.11	2.79	0.74	0.29	2.20
1	184	3.94	0.10	0.08	0.34	0.12	0.94	3.76	0.07	0.03	1.12	0.63	0.11	2.74	0.73	0.29	2.16
1	185	3.85	0.12	0.08	0.32	0.12	0.93	3.85	0.14	0.08	1.13	0.65	0.11	2.92	0.79	0.38	3.21
1	186	3.74	0.14	0.08	0.31	0.11	0.94	3.81	0.10	0.03	1.12	0.72	0.12	3.34	0.90	0.80	2.92
1	187	3.96	0.13	0.07	0.30	0.11	0.91	3.76	0.07	0.03	1.10	0.67	0.11	3.16	1.06	0.88	2.28
1	188	4.25	0.10	0.07	0.29	0.10	0.87	3.76	0.06	0.03	1.10	0.64	0.11	2.93	0.93	0.56	2.10
1	189	4.26	0.14	0.13	0.73	0.10	0.94	3.91	0.18	0.09	1.03	0.64	0.11	2.92	0.84	0.40	2.05
1	190	4.31	0.24	0.13	0.99	0.14	1.00	4.22	0.50	0.29	1.07	0.68	0.12	2.92	0.80	0.36	2.15
1	191	4.21	0.25	0.08	0.49	0.18	0.93	4.09	0.26	0.04	1.10	0.94	0.16	3.38	0.83	0.63	2.26
1	192	4.13	0.20	0.06	0.31	0.13	0.69	3.99	0.11	0.03	1.10	1.03	0.18	3.00	0.81	0.39	1.99
1	193	4.10	0.16	0.06	0.25	0.10	0.69	3.80	0.09	0.03	1.10	0.86	0.15	2.92	0.80	0.34	1.93
1	194	4.14	0.15	0.05	0.22	0.09	0.70	3.78	0.09	0.03	1.09	0.74	0.13	2.88	0.75	0.39	1.89
1	195	4.18	0.15	0.06	0.24	0.09	0.81	3.91	0.18	0.06	1.10	0.68	0.12	2.87	0.73	0.33	2.30
1	196	4.14	0.15	0.06	0.33	0.10	0.97	4.65	0.15	0.03	1.10	0.77	0.13	2.92	0.75	0.43	2.64
1	197	4.10	0.15	0.05	0.25	0.09	0.88	4.09	0.11	0.03	1.10	0.71	0.12	2.89	0.71	0.37	2.04

Following the instructions for this template, save the file as a formatted (space delimited) text file. Ensure that the name of the formatted text file matches the name of the BASINFLOW file in FILENAME.DAT.

Step 3: Modify FLOWFILE

Update the FLOWFILE to include the water quality distributions for Smith Creek. The following screen shots show the rows that need to be added to FLOWFILE to include Smith Creek. Several blocks need to be updated to include a row for Smith Creek, even though the data is not used in the current model configuration. For example, the first several blocks contain input data for simulating boundary flows using internal subroutines but this data is not used in favour of reading the boundary flow data from the BASINFLOW file.




```
Reach 24                    0.02
Reach 25                    0.01
Reach 26                    0.04
Reach 28                    0.01
Reach 29                    0.05
Reach 30                    0.02
Reach 32                    0.03
Reach 33                    0.01
Reach 34                    0.01
Reach 35                    0.01
Reach 36                    0.05
Reach 37                    0.01
Reach 38                    0.07
Reach 39                    0.01
Reach 43                    0.01
Reach 45                    0.02
Reach 46                    0.02
Reach 47                    0.01
Reach 48                    0.03
Reach 49                    0.05
Reach 51                    0.02
Reach 52                    0.03
Reach 53                    0.01
Reach 54                    0.03
Reach 55                    0.01
Reach 57                    0.02
Reach 58                    0.10
Reach 59                    0.01
BACKGROUND VALUES
TYPE OF CALCULATION TO BE USED
SHAND DAM             4  4  4  4  4  4
IRVINE CREEK          4  4  4  4  4  4
CARROLL CREEK         4  4  4  4  4  4
SWAN CREEK            4  4  4  4  4  4
COX CREEK             4  4  4  4  4  4
CANAGAGIGUE           4  4  4  4  4  4
CONESTOGO             4  4  4  4  4  4
LAUREL                4  4  4  4  4  4
SCHNEIDERS            4  4  4  4  4  4
SPEED RIVER           4  4  4  4  4  4
ERAMOSA               4  4  4  4  4  4
SMITH CREEK           4  4  4  4  4  4
NITH RIVER            4  4  4  4  4  4
WHITEMANS             4  4  4  4  4  4
FAIRCHILD             4  4  4  4  4  4
LOCAL INFLOW          4  4  4  4  4  4
REG_FLOW_MINIMUM   :    J    :    F    :    M    :    A    :    M    :    J    :    J    :    A    :    S    :    O    :    N    :    D    :
SHAND DAM             000.      000.      000.      000.      000.      000.      000.      000.      000.      000.      000.      000.
IRVINE CREEK          000.      000.      000.      000.      000.      000.      000.      000.      000.      000.      000.      000.
CARROLL CREEK         000.      000.      000.      000.      000.      000.      000.      000.      000.      000.      000.      000.
SWAN CREEK            000.      000.      000.      000.      000.      000.      000.      000.      000.      000.      000.      000.
COX CREEK             000.      000.      000.      000.      000.      000.      000.      000.      000.      000.      000.      000.
CANAGAGIGUE           000.      000.      000.      000.      000.      000.      000.      000.      000.      000.      000.      000.
CONESTOGO             000.      000.      000.      000.      000.      000.      000.      000.      000.      000.      000.      000.
LAUREL                000.      000.      000.      000.      000.      000.      000.      000.      000.      000.      000.      000.
SCHNEIDER             000.      000.      000.      000.      000.      000.      000.      000.      000.      000.      000.      000.
SPEED RIVER           000.      000.      000.      000.      000.      000.      000.      000.      000.      000.      000.      000.
ERAMOSA               000.      000.      000.      000.      000.      000.      000.      000.      000.      000.      000.      000.
NITH RIVER            000.      000.      000.      000.      000.      000.      000.      000.      000.      000.      000.      000.
WHITEMANS             000.      000.      000.      000.      000.      000.      000.      000.      000.      000.      000.      000.
FAIRCHILD             000.      000.      000.      000.      000.      000.      000.      000.      000.      000.      000.      000.
LOCAL INFLOW          000.      000.      000.      000.      000.      000.      000.      000.      000.      000.      000.      000.
LARGEST EXPECTED FLOW 12 PER BOUNDARY FLOW
                       J         F         M         A         M         J         J         A         S         O         N         D
SHAND DAM             6000.     6000.     6000.     6000.     6000.     6000.     6000.     6000.     6000.     6000.     6000.     6000.
IRVINE CREEK          6000.     6000.     6000.     6000.     6000.     6000.     6000.     6000.     6000.     6000.     6000.     6000.
CARROLL CREEK         6000.     6000.     6000.     6000.     6000.     6000.     6000.     6000.     6000.     6000.     6000.     6000.
SWAN CREEK            6000.     6000.     6000.     6000.     6000.     6000.     6000.     6000.     6000.     6000.     6000.     6000.
COX CREEK             6000.     6000.     6000.     6000.     6000.     6000.     6000.     6000.     6000.     6000.     6000.     6000.
CANAGAGIGUE           6000.     6000.     6000.     6000.     6000.     6000.     6000.     6000.     6000.     6000.     6000.     6000.
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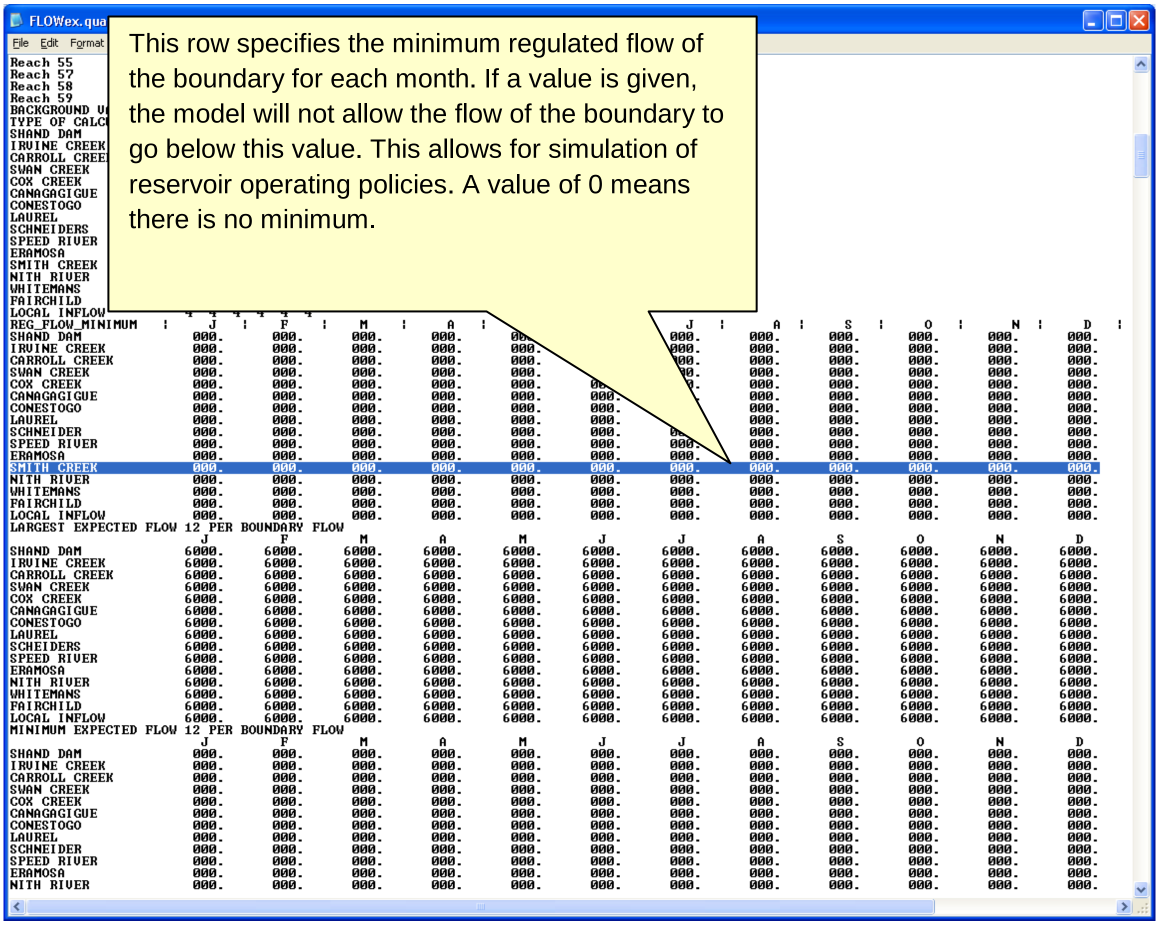
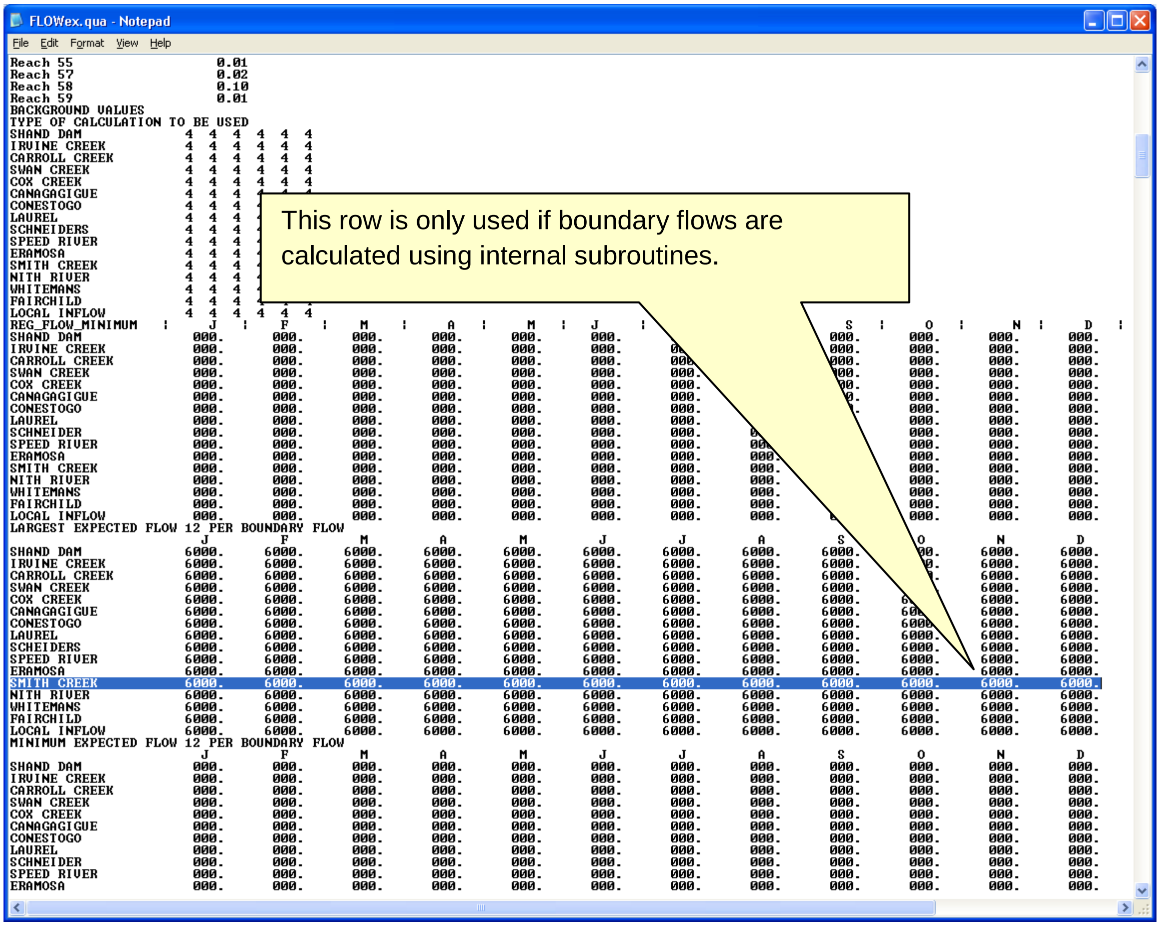
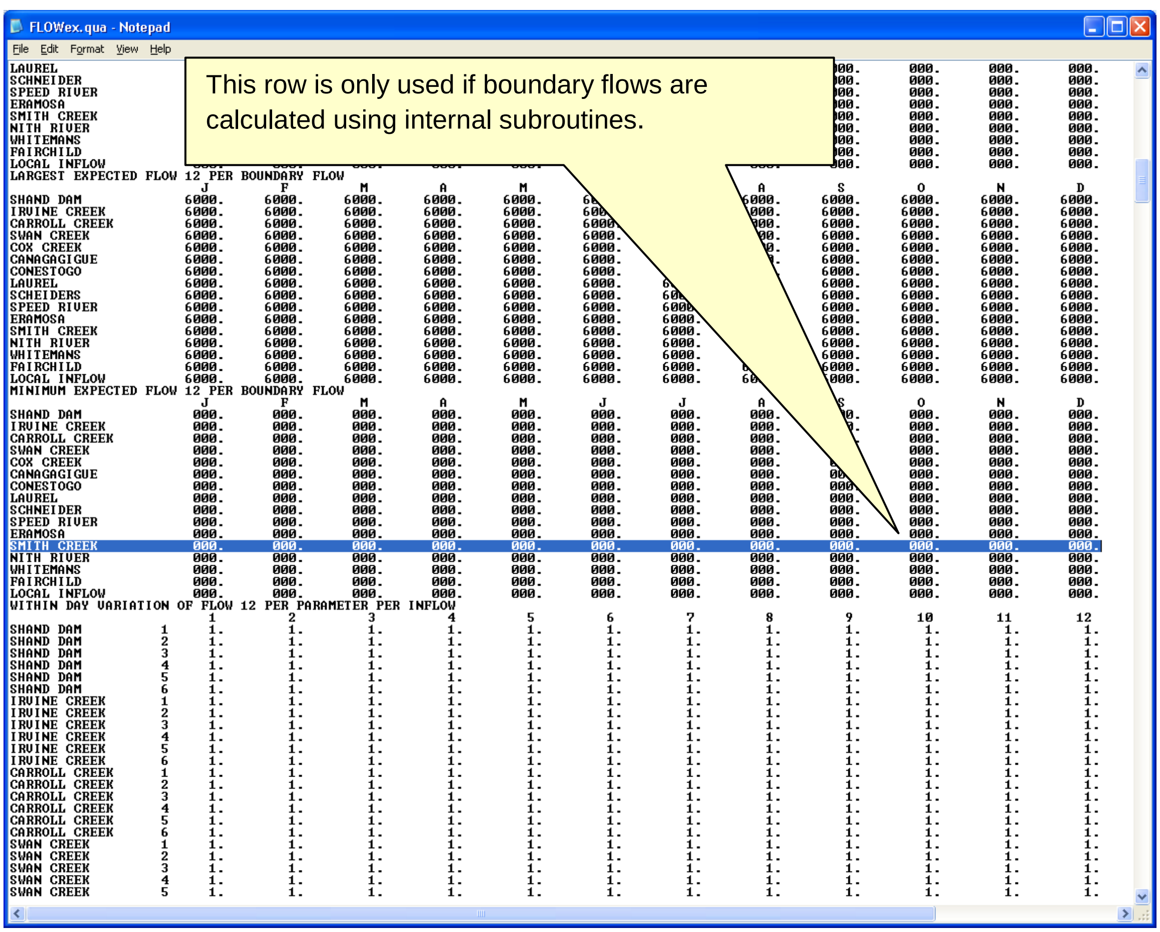

FLOWex.qua
File Edit Format
This row specifies the minimum regulated flow of the boundary for each month. If a value is given, the model will not allow the flow of the boundary to go below this value. This allows for simulation of reservoir operating policies. A value of 0 means there is no minimum.
Reach 55
Reach 57
Reach 58
Reach 59
SHAND DAM
IRVINE CREEK
SWAN CREEK
COX CREEK
CANAGAGIGUE
CONESTOGO
LAUREL
SCHNEIDERS
SPEED RIVER
ERAMOSA
SMITH CREEK
NITH RIVER
WHITEMANS
FAIRCHILD
LOCAL INFLOW
REG_FLOW_MINIMUM ¦ J ¦ F ¦ M ¦ A ¦ J ¦ A ¦ S ¦ O ¦ N ¦ D ¦
SHAND DAM 000. 000. 000. 000. 000. 000. 000. 000. 000. 000.
IRVINE CREEK 000. 000. 000. 000. 000. 000. 000. 000. 000. 000. 000.
CARROLL CREEK 000. 000. 000. 000. 000. 000. 000. 000. 000. 000.
SWAN CREEK 000. 000. 000. 000. 000. 000. 000. 000. 000. 000.
COX CREEK 000. 000. 000. 000. 000. 000. 000. 000. 000. 000.
CANAGAGIGUE 000. 000. 000. 000. 000. 000. 000. 000. 000. 000. 000.
CONESTOGO 000. 000. 000. 000. 000. 000. 000. 000. 000. 000. 000.
LAUREL 000. 000. 000. 000. 000. 000. 000. 000. 000. 000. 000.
SCHNEIDER 000. 000. 000. 000. 000. 000. 000. 000. 000. 000. 000.
SPEED RIVER 000. 000. 000. 000. 000. 000. 000. 000. 000. 000. 000. 000.
ERAMOSA 000. 000. 000. 000. 000. 000. 000. 000. 000. 000. 000. 000.
SMITH CREEK 000. 000. 000. 000. 000. 000. 000. 000. 000. 000. 000. 000.
NITH RIVER 000. 000. 000. 000. 000. 000. 000. 000. 000. 000. 000. 000.
WHITEMANS 000. 000. 000. 000. 000. 000. 000. 000. 000. 000. 000. 000.
FAIRCHILD 000. 000. 000. 000. 000. 000. 000. 000. 000. 000. 000. 000.
LOCAL INFLOW 000. 000. 000. 000. 000. 000. 000. 000. 000. 000. 000. 000.
LARGEST EXPECTED FLOW 12 PER BOUNDARY FLOW
J F M A M J J A S O N D
SHAND DAM 6000. 6000. 6000. 6000. 6000. 6000. 6000. 6000. 6000. 6000. 6000. 6000.
IRVINE CREEK 6000. 6000. 6000. 6000. 6000. 6000. 6000. 6000. 6000. 6000. 6000. 6000.
CARROLL CREEK 6000. 6000. 6000. 6000. 6000. 6000. 6000. 6000. 6000. 6000. 6000. 6000.
SWAN CREEK 6000. 6000. 6000. 6000. 6000. 6000. 6000. 6000. 6000. 6000. 6000. 6000.
COX CREEK 6000. 6000. 6000. 6000. 6000. 6000. 6000. 6000. 6000. 6000. 6000. 6000.
CANAGAGIGUE 6000. 6000. 6000. 6000. 6000. 6000. 6000. 6000. 6000. 6000. 6000. 6000.
CONESTOGO 6000. 6000. 6000. 6000. 6000. 6000. 6000. 6000. 6000. 6000. 6000. 6000.
LAUREL 6000. 6000. 6000. 6000. 6000. 6000. 6000. 6000. 6000. 6000. 6000. 6000.
SCHEIDERS 6000. 6000. 6000. 6000. 6000. 6000. 6000. 6000. 6000. 6000. 6000. 6000.
SPEED RIVER 6000. 6000. 6000. 6000. 6000. 6000. 6000. 6000. 6000. 6000. 6000. 6000.
ERAMOSA 6000. 6000. 6000. 6000. 6000. 6000. 6000. 6000. 6000. 6000. 6000. 6000.
NITH RIVER 6000. 6000. 6000. 6000. 6000. 6000. 6000. 6000. 6000. 6000. 6000. 6000.
WHITEMANS 6000. 6000. 6000. 6000. 6000. 6000. 6000. 6000. 6000. 6000. 6000. 6000.
FAIRCHILD 6000. 6000. 6000. 6000. 6000. 6000. 6000. 6000. 6000. 6000. 6000. 6000.
LOCAL INFLOW 6000. 6000. 6000. 6000. 6000. 6000. 6000. 6000. 6000. 6000. 6000. 6000.
MINIMUM EXPECTED FLOW 12 PER BOUNDARY FLOW
J F M A M J J A S O N D
SHAND DAM 000. 000. 000. 000. 000. 000. 000. 000. 000. 000. 000. 000.
IRVINE CREEK 000. 000. 000. 000. 000. 000. 000. 000. 000. 000. 000. 000.
CARROLL CREEK 000. 000. 000. 000. 000. 000. 000. 000. 000. 000. 000. 000.
SWAN CREEK 000. 000. 000. 000. 000. 000. 000. 000. 000. 000. 000. 000.
COX CREEK 000. 000. 000. 000. 000. 000. 000. 000. 000. 000. 000. 000.
CANAGAGIGUE 000. 000. 000. 000. 000. 000. 000. 000. 000. 000. 000. 000.
CONESTOGO 000. 000. 000. 000. 000. 000. 000. 000. 000. 000. 000. 000.
LAUREL 000. 000. 000. 000. 000. 000. 000. 000. 000. 000. 000. 000.
SCHNEIDER 000. 000. 000. 000. 000. 000. 000. 000. 000. 000. 000. 000.
SPEED RIVER 000. 000. 000. 000. 000. 000. 000. 000. 000. 000. 000. 000.
ERAMOSA 000. 000. 000. 000. 000. 000. 000. 000. 000. 000. 000. 000.
NITH RIVER 000. 000. 000. 000. 000. 000. 000. 000. 000. 000. 000. 000.




```
Reach 55                  0.01
Reach 57                  0.02
Reach 58                  0.10
Reach 59                  0.01
BACKGROUND VALUES
TYPE OF CALCULATION TO BE USED
SHAND DAM              4  4  4  4  4  4
IRVINE CREEK           4  4  4  4  4  4
CARROLL CREEK          4  4  4  4  4  4
SWAN CREEK             4  4  4  4  4  4
COX CREEK              4  4  4  4  4  4
CANAGAGIGUE            4  4  4
CONESTOGO              4  4  4
LAUREL                 4  4  4
SCHNEIDERS             4  4  4
SPEED RIVER            4  4  4
ERAMOSA                4  4  4
SMITH CREEK            4  4  4
NITH RIVER             4  4  4
WHITEMANS              4  4  4
FAIRCHILD              4  4  4
LOCAL INFLOW           4  4  4  4  4  4
REG_FLOW_MINIMUM   :    J    :    F    :    M    :    A    :    M    :    J    :                        S    :    O    :    N    :    D    :
SHAND DAM              000.      000.      000.      000.      000.      000.                          000.      000.      000.      000.
IRVINE CREEK           000.      000.      000.      000.      000.      000.      00                  000.      000.      000.      000.
CARROLL CREEK          000.      000.      000.      000.      000.      000.      000                 000.      000.      000.      000.
SWAN CREEK             000.      000.      000.      000.      000.      000.      000.                 00.      000.      000.      000.
COX CREEK              000.      000.      000.      000.      000.      000.      000.                 00.      000.      000.      000.
CANAGAGIGUE            000.      000.      000.      000.      000.      000.      000.                  0.      000.      000.      000.
CONESTOGO              000.      000.      000.      000.      000.      000.      000.                   .      000.      000.      000.
LAUREL                 000.      000.      000.      000.      000.      000.      000.                          000.      000.      000.
SCHNEIDER              000.      000.      000.      000.      000.      000.      000.      0                   000.      000.      000.
SPEED RIVER            000.      000.      000.      000.      000.      000.      000.      00                  000.      000.      000.
ERAMOSA                000.      000.      000.      000.      000.      000.      000.      000.                000.      000.      000.
SMITH CREEK            000.      000.      000.      000.      000.      000.      000.      000.                000.      000.      000.
NITH RIVER             000.      000.      000.      000.      000.      000.      000.      000.                000.      000.      000.
WHITEMANS              000.      000.      000.      000.      000.      000.      000.      000.                000.      000.      000.
FAIRCHILD              000.      000.      000.      000.      000.      000.      000.      000.                000.      000.      000.
LOCAL INFLOW           000.      000.      000.      000.      000.      000.      000.      000.                000.      000.      000.
LARGEST EXPECTED FLOW 12 PER BOUNDARY FLOW
                        J         F         M         A         M         J         J         A         S         O         N         D
SHAND DAM              6000.     6000.     6000.     6000.     6000.     6000.     6000.     6000.     6000.      00.     6000.     6000.
IRVINE CREEK           6000.     6000.     6000.     6000.     6000.     6000.     6000.     6000.     6000.       0.     6000.     6000.
CARROLL CREEK          6000.     6000.     6000.     6000.     6000.     6000.     6000.     6000.     6000.        .     6000.     6000.
SWAN CREEK             6000.     6000.     6000.     6000.     6000.     6000.     6000.     6000.     6000.               6000.     6000.
COX CREEK              6000.     6000.     6000.     6000.     6000.     6000.     6000.     6000.     6000.     6         6000.     6000.
CANAGAGIGUE            6000.     6000.     6000.     6000.     6000.     6000.     6000.     6000.     6000.     60        6000.     6000.
CONESTOGO              6000.     6000.     6000.     6000.     6000.     6000.     6000.     6000.     6000.     6000      6000.     6000.
LAUREL                 6000.     6000.     6000.     6000.     6000.     6000.     6000.     6000.     6000.     6000.     6000.     6000.
SCHEIDERS              6000.     6000.     6000.     6000.     6000.     6000.     6000.     6000.     6000.     6000.     6000.     6000.
SPEED RIVER            6000.     6000.     6000.     6000.     6000.     6000.     6000.     6000.     6000.     6000.     6000.     6000.
ERAMOSA                6000.     6000.     6000.     6000.     6000.     6000.     6000.     6000.     6000.     6000.     6000.     6000.
SMITH CREEK            6000.     6000.     6000.     6000.     6000.     6000.     6000.     6000.     6000.     6000.     6000.     6000.
NITH RIVER             6000.     6000.     6000.     6000.     6000.     6000.     6000.     6000.     6000.     6000.     6000.     6000.
WHITEMANS              6000.     6000.     6000.     6000.     6000.     6000.     6000.     6000.     6000.     6000.     6000.     6000.
FAIRCHILD              6000.     6000.     6000.     6000.     6000.     6000.     6000.     6000.     6000.     6000.     6000.     6000.
LOCAL INFLOW           6000.     6000.     6000.     6000.     6000.     6000.     6000.     6000.     6000.     6000.     6000.     6000.
MINIMUM EXPECTED FLOW 12 PER BOUNDARY FLOW
                        J         F         M         A         M         J         J         A         S         O         N         D
SHAND DAM              000.      000.      000.      000.      000.      000.      000.      000.      000.      000.      000.      000.
IRVINE CREEK           000.      000.      000.      000.      000.      000.      000.      000.      000.      000.      000.      000.
CARROLL CREEK          000.      000.      000.      000.      000.      000.      000.      000.      000.      000.      000.      000.
SWAN CREEK             000.      000.      000.      000.      000.      000.      000.      000.      000.      000.      000.      000.
COX CREEK              000.      000.      000.      000.      000.      000.      000.      000.      000.      000.      000.      000.
CANAGAGIGUE            000.      000.      000.      000.      000.      000.      000.      000.      000.      000.      000.      000.
CONESTOGO              000.      000.      000.      000.      000.      000.      000.      000.      000.      000.      000.      000.
LAUREL                 000.      000.      000.      000.      000.      000.      000.      000.      000.      000.      000.      000.
SCHNEIDER              000.      000.      000.      000.      000.      000.      000.      000.      000.      000.      000.      000.
SPEED RIVER            000.      000.      000.      000.      000.      000.      000.      000.      000.      000.      000.      000.
ERAMOSA                000.      000.      000.      000.      000.      000.      000.      000.      000.      000.      000.      000.
```




```
LAUREL                                                                                          00.      000.      000.      000.
SCHNEIDER                                                                                       00.      000.      000.      000.
SPEED RIVER                                                                                     00.      000.      000.      000.
ERAMOSA                                                                                         00.      000.      000.      000.
SMITH CREEK                                                                                     00.      000.      000.      000.
NITH RIVER                                                                                      00.      000.      000.      000.
WHITEMANS                                                                                       00.      000.      000.      000.
FAIRCHILD                                                                                       00.      000.      000.      000.
LOCAL INFLOW                                                                                    00.      000.      000.      000.
LARGEST EXPECTED FLOW 12 PER BOUNDARY FLOW
                        J         F         M         A         M                             A         S         O         N         D
SHAND DAM              6000.     6000.     6000.     6000.     6000.     6                   6000.     6000.     6000.     6000.     6000.
IRVINE CREEK           6000.     6000.     6000.     6000.     6000.     60                   000.     6000.     6000.     6000.     6000.
CARROLL CREEK          6000.     6000.     6000.     6000.     6000.     6000                  00.     6000.     6000.     6000.     6000.
SWAN CREEK             6000.     6000.     6000.     6000.     6000.     6000.                  0.     6000.     6000.     6000.     6000.
COX CREEK              6000.     6000.     6000.     6000.     6000.     6000.                  0.     6000.     6000.     6000.     6000.
CANAGAGIGUE            6000.     6000.     6000.     6000.     6000.     6000.                   .     6000.     6000.     6000.     6000.
CONESTOGO              6000.     6000.     6000.     6000.     6000.     6000.                         6000.     6000.     6000.     6000.
LAUREL                 6000.     6000.     6000.     6000.     6000.     6000.     6                   6000.     6000.     6000.     6000.
SCHEIDERS              6000.     6000.     6000.     6000.     6000.     6000.     60                  6000.     6000.     6000.     6000.
SPEED RIVER            6000.     6000.     6000.     6000.     6000.     6000.     6000                6000.     6000.     6000.     6000.
ERAMOSA                6000.     6000.     6000.     6000.     6000.     6000.     6000.               6000.     6000.     6000.     6000.
SMITH CREEK            6000.     6000.     6000.     6000.     6000.     6000.     6000.               6000.     6000.     6000.     6000.
NITH RIVER             6000.     6000.     6000.     6000.     6000.     6000.     6000.               6000.     6000.     6000.     6000.
WHITEMANS              6000.     6000.     6000.     6000.     6000.     6000.     6000.               6000.     6000.     6000.     6000.
FAIRCHILD              6000.     6000.     6000.     6000.     6000.     6000.     6000.     6         6000.     6000.     6000.     6000.
LOCAL INFLOW           6000.     6000.     6000.     6000.     6000.     6000.     6000.     60         000.     6000.     6000.     6000.
MINIMUM EXPECTED FLOW 12 PER BOUNDARY FLOW
                        J         F         M         A         M         J         J         A         S         O         N         D
SHAND DAM              000.      000.      000.      000.      000.      000.      000.      000.        0.      000.      000.      000.
IRVINE CREEK           000.      000.      000.      000.      000.      000.      000.      000.         .      000.      000.      000.
CARROLL CREEK          000.      000.      000.      000.      000.      000.      000.      000.                000.      000.      000.
SWAN CREEK             000.      000.      000.      000.      000.      000.      000.      000.                000.      000.      000.
COX CREEK              000.      000.      000.      000.      000.      000.      000.      000.      0         000.      000.      000.
CANAGAGIGUE            000.      000.      000.      000.      000.      000.      000.      000.      00        000.      000.      000.
CONESTOGO              000.      000.      000.      000.      000.      000.      000.      000.      000       000.      000.      000.
LAUREL                 000.      000.      000.      000.      000.      000.      000.      000.      000.      000.      000.      000.
SCHNEIDER              000.      000.      000.      000.      000.      000.      000.      000.      000.      000.      000.      000.
SPEED RIVER            000.      000.      000.      000.      000.      000.      000.      000.      000.      000.      000.      000.
ERAMOSA                000.      000.      000.      000.      000.      000.      000.      000.      000.      000.      000.      000.
SMITH CREEK            000.      000.      000.      000.      000.      000.      000.      000.      000.      000.      000.      000.
NITH RIVER             000.      000.      000.      000.      000.      000.      000.      000.      000.      000.      000.      000.
WHITEMANS              000.      000.      000.      000.      000.      000.      000.      000.      000.      000.      000.      000.
FAIRCHILD              000.      000.      000.      000.      000.      000.      000.      000.      000.      000.      000.      000.
LOCAL INFLOW           000.      000.      000.      000.      000.      000.      000.      000.      000.      000.      000.      000.
WITHIN DAY VARIATION OF FLOW 12 PER PARAMETER PER INFLOW
                          1         2         3         4         5         6         7         8         9        10        11        12
SHAND DAM          1      1.        1.        1.        1.        1.        1.        1.        1.        1.        1.        1.        1.
SHAND DAM          2      1.        1.        1.        1.        1.        1.        1.        1.        1.        1.        1.        1.
SHAND DAM          3      1.        1.        1.        1.        1.        1.        1.        1.        1.        1.        1.        1.
SHAND DAM          4      1.        1.        1.        1.        1.        1.        1.        1.        1.        1.        1.        1.
SHAND DAM          5      1.        1.        1.        1.        1.        1.        1.        1.        1.        1.        1.        1.
SHAND DAM          6      1.        1.        1.        1.        1.        1.        1.        1.        1.        1.        1.        1.
IRVINE CREEK       1      1.        1.        1.        1.        1.        1.        1.        1.        1.        1.        1.        1.
IRVINE CREEK       2      1.        1.        1.        1.        1.        1.        1.        1.        1.        1.        1.        1.
IRVINE CREEK       3      1.        1.        1.        1.        1.        1.        1.        1.        1.        1.        1.        1.
IRVINE CREEK       4      1.        1.        1.        1.        1.        1.        1.        1.        1.        1.        1.        1.
IRVINE CREEK       5      1.        1.        1.        1.        1.        1.        1.        1.        1.        1.        1.        1.
IRVINE CREEK       6      1.        1.        1.        1.        1.        1.        1.        1.        1.        1.        1.        1.
CARROLL CREEK      1      1.        1.        1.        1.        1.        1.        1.        1.        1.        1.        1.        1.
CARROLL CREEK      2      1.        1.        1.        1.        1.        1.        1.        1.        1.        1.        1.        1.
CARROLL CREEK      3      1.        1.        1.        1.        1.        1.        1.        1.        1.        1.        1.        1.
CARROLL CREEK      4      1.        1.        1.        1.        1.        1.        1.        1.        1.        1.        1.        1.
CARROLL CREEK      5      1.        1.        1.        1.        1.        1.        1.        1.        1.        1.        1.        1.
CARROLL CREEK      6      1.        1.        1.        1.        1.        1.        1.        1.        1.        1.        1.        1.
SWAN CREEK         1      1.        1.        1.        1.        1.        1.        1.        1.        1.        1.        1.        1.
SWAN CREEK         2      1.        1.        1.        1.        1.        1.        1.        1.        1.        1.        1.        1.
SWAN CREEK         3      1.        1.        1.        1.        1.        1.        1.        1.        1.        1.        1.        1.
SWAN CREEK         4      1.        1.        1.        1.        1.        1.        1.        1.        1.        1.        1.        1.
SWAN CREEK         5      1.        1.        1.        1.        1.        1.        1.        1.        1.        1.        1.        1.
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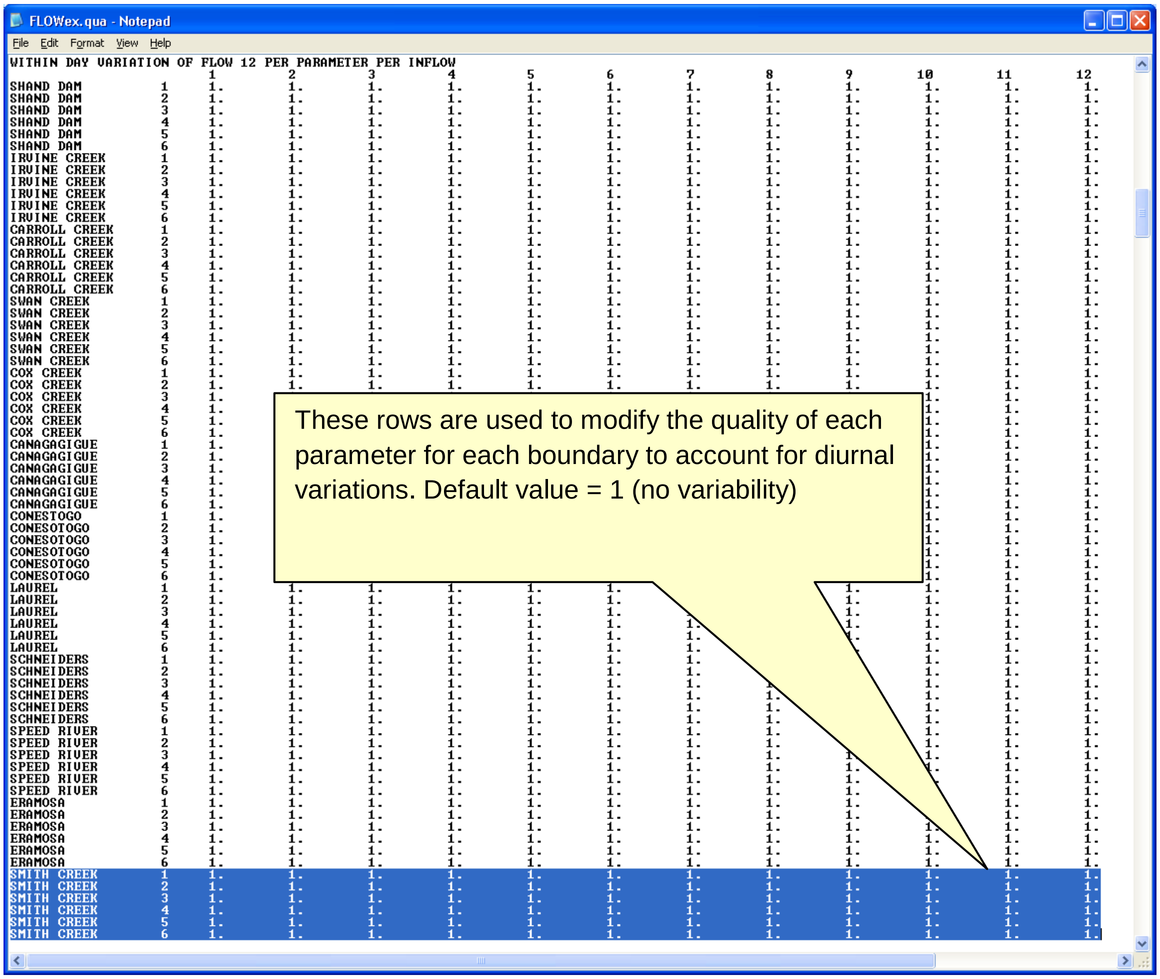
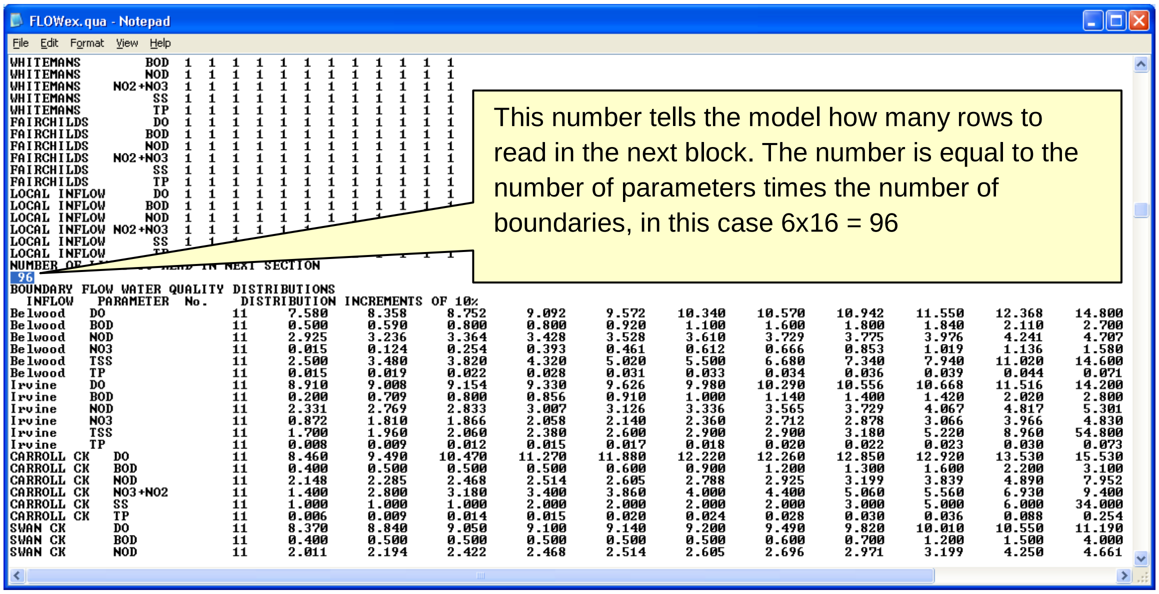
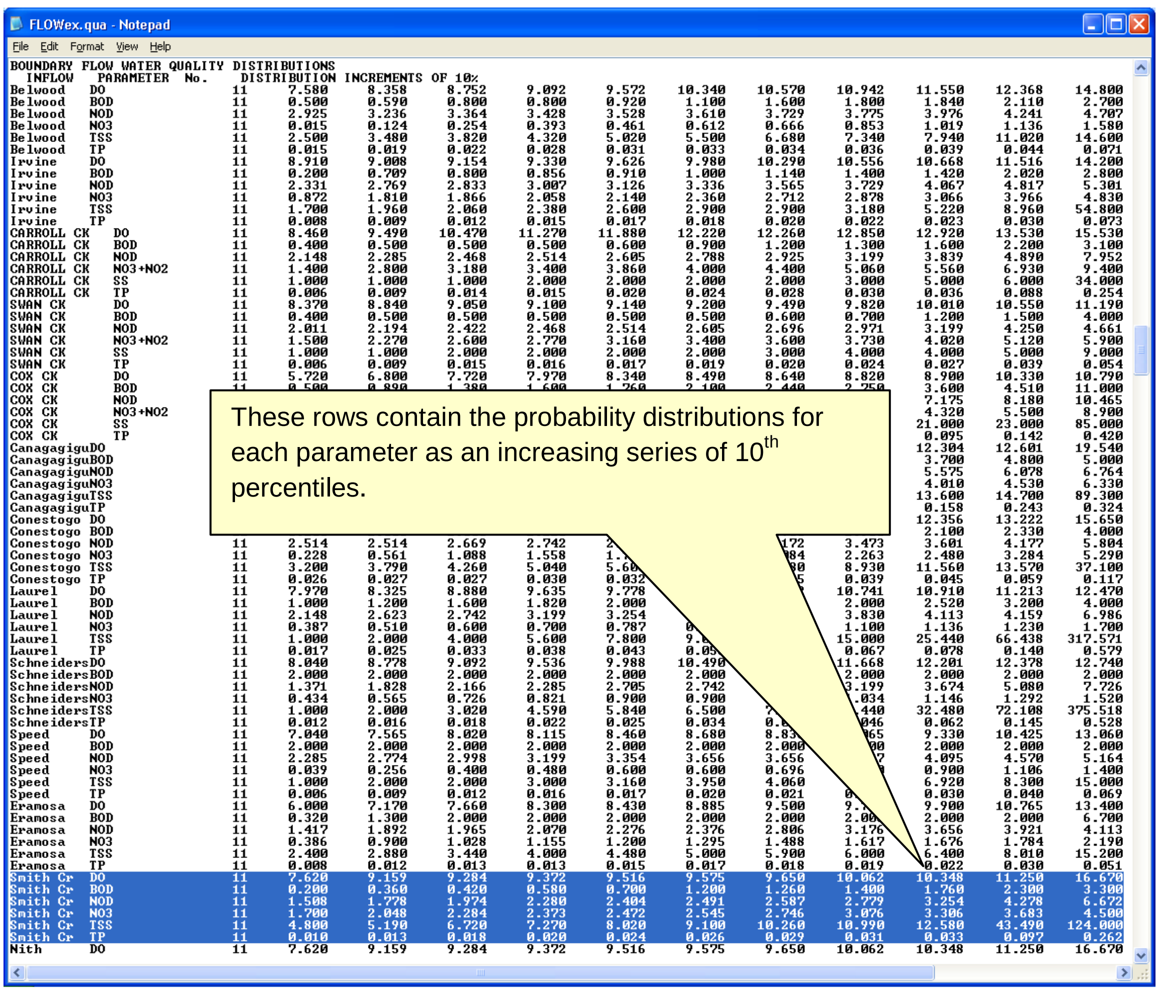


WITHIN DAY VARIATION OF FLOW 12 PER PARAMETER PER INFLOW

		1	2	3	4	5	6	7	8	9	10	11	12
SHAND DAM	1	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
SHAND DAM	2	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
SHAND DAM	3	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
SHAND DAM	4	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
SHAND DAM	5	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
SHAND DAM	6	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
IRVINE CREEK	1	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
IRVINE CREEK	2	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
IRVINE CREEK	3	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
IRVINE CREEK	4	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
IRVINE CREEK	5	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
IRVINE CREEK	6	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
CARROLL CREEK	1	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
CARROLL CREEK	2	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
CARROLL CREEK	3	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
CARROLL CREEK	4	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
CARROLL CREEK	5	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
CARROLL CREEK	6	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
SWAN CREEK	1	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
SWAN CREEK	2	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
SWAN CREEK	3	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
SWAN CREEK	4	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
SWAN CREEK	5	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
SWAN CREEK	6	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
COX CREEK	1	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
COX CREEK	2	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
COX CREEK	3	1.									1.	1.	1.
COX CREEK	4	1.									1.	1.	1.
COX CREEK	5	1.									1.	1.	1.
COX CREEK	6	1.									1.	1.	1.
CANAGAGIGUE	1	1.									1.	1.	1.
CANAGAGIGUE	2	1.									1.	1.	1.
CANAGAGIGUE	3	1.									1.	1.	1.
CANAGAGIGUE	4	1.									1.	1.	1.
CANAGAGIGUE	5	1.									1.	1.	1.
CANAGAGIGUE	6	1.									1.	1.	1.
CONESTOGO	1	1.									1.	1.	1.
CONESOTOGO	2	1.									1.	1.	1.
CONESOTOGO	3	1.									1.	1.	1.
CONESOTOGO	4	1.									1.	1.	1.
CONESOTOGO	5	1.									1.	1.	1.
CONESOTOGO	6	1.									1.	1.	1.
LAUREL	1	1.	1.	1.	1.	1.	1.			1.	1.	1.	1.
LAUREL	2	1.	1.	1.	1.	1.	1.			1.	1.	1.	1.
LAUREL	3	1.	1.	1.	1.	1.	1.			1.	1.	1.	1.
LAUREL	4	1.	1.	1.	1.	1.	1.	1.		1.	1.	1.	1.
LAUREL	5	1.	1.	1.	1.	1.	1.	1.		1.	1.	1.	1.
LAUREL	6	1.	1.	1.	1.	1.	1.	1.			1.	1.	1.
SCHNEIDERS	1	1.	1.	1.	1.	1.	1.	1.			1.	1.	1.
SCHNEIDERS	2	1.	1.	1.	1.	1.	1.	1.			1.	1.	1.
SCHNEIDERS	3	1.	1.	1.	1.	1.	1.	1.			1.	1.	1.
SCHNEIDERS	4	1.	1.	1.	1.	1.	1.	1.	1.		1.	1.	1.
SCHNEIDERS	5	1.	1.	1.	1.	1.	1.	1.	1.		1.	1.	1.
SCHNEIDERS	6	1.	1.	1.	1.	1.	1.	1.	1.		1.	1.	1.
SPEED RIVER	1	1.	1.	1.	1.	1.	1.	1.	1.		1.	1.	1.
SPEED RIVER	2	1.	1.	1.	1.	1.	1.	1.	1.		1.	1.	1.
SPEED RIVER	3	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
SPEED RIVER	4	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
SPEED RIVER	5	1.	1.	1.	1.	1.	1.	1.	1.	1.		1.	1.
SPEED RIVER	6	1.	1.	1.	1.	1.	1.	1.	1.	1.		1.	1.
ERAMOSA	1	1.	1.	1.	1.	1.	1.	1.	1.	1.		1.	1.
ERAMOSA	2	1.	1.	1.	1.	1.	1.	1.	1.	1.		1.	1.
ERAMOSA	3	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
ERAMOSA	4	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
ERAMOSA	5	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
ERAMOSA	6	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
SMITH CREEK	1	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
SMITH CREEK	2	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
SMITH CREEK	3	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
SMITH CREEK	4	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
SMITH CREEK	5	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
SMITH CREEK	6	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.

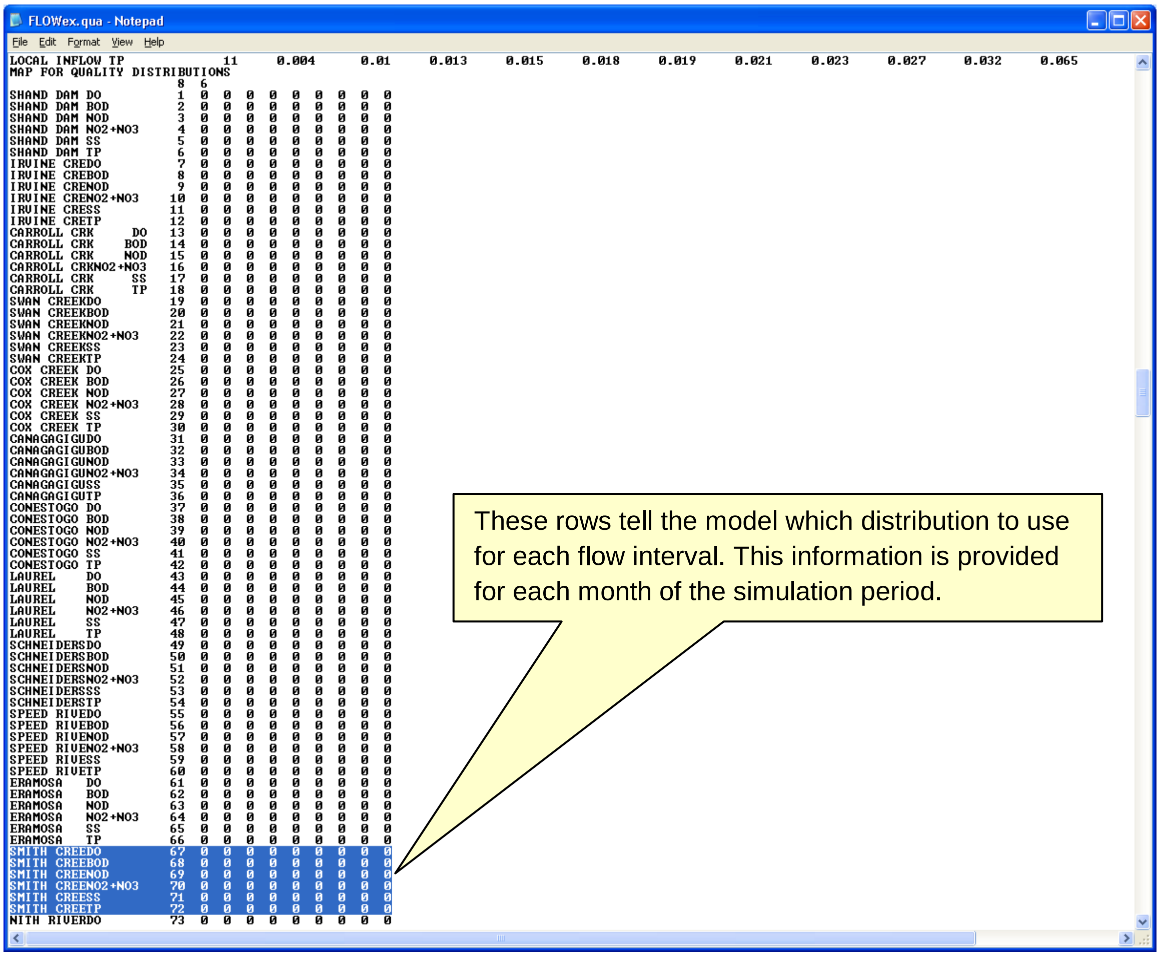
Since the calculation method for boundary water quality is set to Type 4, the model is expecting one probability distribution for each water quality parameter for each boundary or tributary. These distributions are typically developed from representative spot measurements (i.e., over a recent period of time, using consistent sampling and analysis methods, during similar climate/flow/seasonal conditions to those being modeled). Each distribution is entered into the model as a sequence of percentiles in ascending order (i.e., the minimum (0^{th} percentile), 10^{th} percentile, 20^{th} percentile, […], 90^{th} percentile, maximum). The following screen shots show the FLOWFILE being updated to include these new distributions for Smith Creek.


FLOWex.qua - Notepad
File Edit Format View Help
This number tells the model how many rows to read in the next block. The number is equal to the number of parameters times the number of boundaries, in this case 6x16 = 96
96
BOUNDARY FLOW WATER QUALITY DISTRIBUTIONS
INFLOW PARAMETER No. DISTRIBUTION INCREMENTS OF 10%


FLOWex.qua - Notepad
File Edit Format View Help
BOUNDARY FLOW WATER QUALITY DISTRIBUTIONS
INFLOW PARAMETER No. DISTRIBUTION INCREMENTS OF 10%
These rows contain the probability distributions for each parameter as an increasing series of 10th percentiles.

Appendix A

The following screen shot shows the map of boundary water quality distributions that tells the model which distribution in the previous block to use for boundary quality calculations. For each boundary, there is one row for each parameter and 10 columns for the flow intervals. For Type 4 calculations, there is only one flow interval and therefore the first column must be populated with the row number of the probability distribution in the previous block. For example, the distribution for total phosphorus for Smith Creek is contained on row 72 of the previous block. If the calculation method is Type 2, 3 or 5 where there are multiple flow intervals, this map must contain the row number of the distribution to be used for each flow interval.

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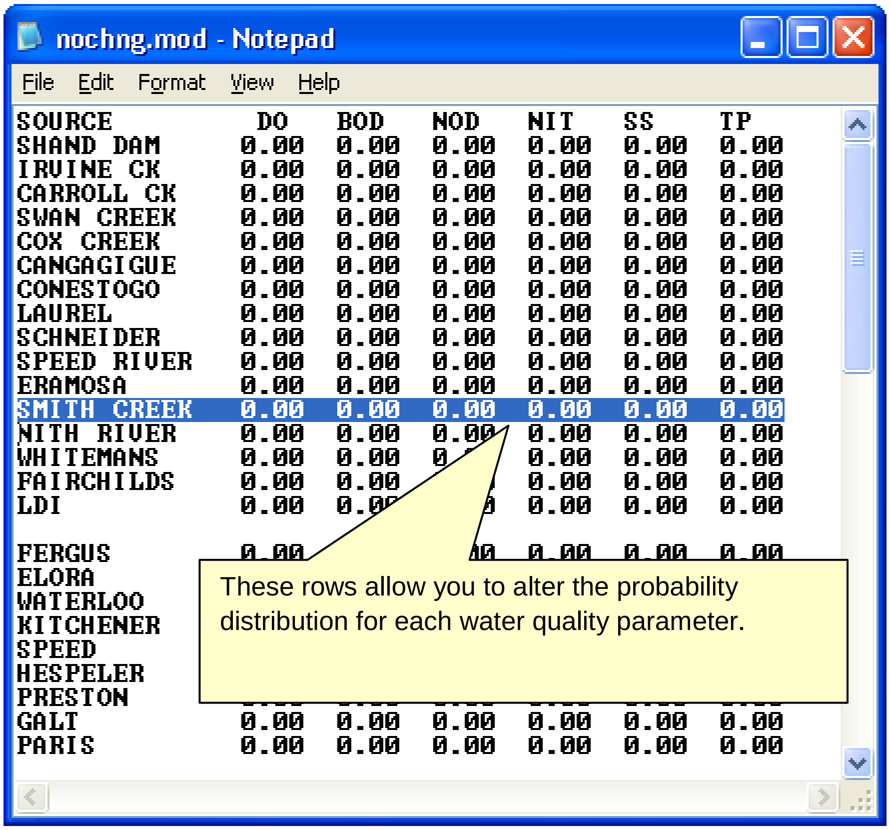
LOCAL INFLOW TP             11     0.004     0.01     0.013     0.015     0.018     0.019     0.021     0.023     0.027     0.032     0.065
MAP FOR QUALITY DISTRIBUTIONS
                      8  6
SHAND DAM DO          1  0  0  0  0  0  0  0  0  0
SHAND DAM BOD         2  0  0  0  0  0  0  0  0  0
SHAND DAM NOD         3  0  0  0  0  0  0  0  0  0
SHAND DAM NO2+NO3     4  0  0  0  0  0  0  0  0  0
SHAND DAM SS          5  0  0  0  0  0  0  0  0  0
SHAND DAM TP          6  0  0  0  0  0  0  0  0  0
IRVINE CREDO          7  0  0  0  0  0  0  0  0  0
IRVINE CREBOD         8  0  0  0  0  0  0  0  0  0
IRVINE CRENOD         9  0  0  0  0  0  0  0  0  0
IRVINE CRENO2+NO3    10  0  0  0  0  0  0  0  0  0
IRVINE CRESS         11  0  0  0  0  0  0  0  0  0
IRVINE CRETP         12  0  0  0  0  0  0  0  0  0
CARROLL CRK     DO   13  0  0  0  0  0  0  0  0  0
CARROLL CRK    BOD   14  0  0  0  0  0  0  0  0  0
CARROLL CRK    NOD   15  0  0  0  0  0  0  0  0  0
CARROLL CRKNO2+NO3   16  0  0  0  0  0  0  0  0  0
CARROLL CRK     SS   17  0  0  0  0  0  0  0  0  0
CARROLL CRK     TP   18  0  0  0  0  0  0  0  0  0
SWAN CREEKDO         19  0  0  0  0  0  0  0  0  0
SWAN CREEKBOD        20  0  0  0  0  0  0  0  0  0
SWAN CREEKNOD        21  0  0  0  0  0  0  0  0  0
SWAN CREEKNO2+NO3    22  0  0  0  0  0  0  0  0  0
SWAN CREEKSS         23  0  0  0  0  0  0  0  0  0
SWAN CREEKTP         24  0  0  0  0  0  0  0  0  0
COX CREEK DO         25  0  0  0  0  0  0  0  0  0
COX CREEK BOD        26  0  0  0  0  0  0  0  0  0
COX CREEK NOD        27  0  0  0  0  0  0  0  0  0
COX CREEK NO2+NO3    28  0  0  0  0  0  0  0  0  0
COX CREEK SS         29  0  0  0  0  0  0  0  0  0
COX CREEK TP         30  0  0  0  0  0  0  0  0  0
CANAGAGIGUDO         31  0  0  0  0  0  0  0  0  0
CANAGAGIGUBOD        32  0  0  0  0  0  0  0  0  0
CANAGAGIGUNOD        33  0  0  0  0  0  0  0  0  0
CANAGAGIGUNO2+NO3    34  0  0  0  0  0  0  0  0  0
CANAGAGIGUSS         35  0  0  0  0  0  0  0  0  0
CANAGAGIGUTP         36  0  0  0  0  0  0  0  0  0
CONESTOGO DO         37  0  0  0  0  0  0  0  0  0
CONESTOGO BOD        38  0  0  0  0  0  0  0  0  0
CONESTOGO NOD        39  0  0  0  0  0  0  0  0  0
CONESTOGO NO2+NO3    40  0  0  0  0  0  0  0  0  0
CONESTOGO SS         41  0  0  0  0  0  0  0  0  0
CONESTOGO TP         42  0  0  0  0  0  0  0  0  0
LAUREL    DO         43  0  0  0  0  0  0  0  0  0
LAUREL    BOD        44  0  0  0  0  0  0  0  0  0
LAUREL    NOD        45  0  0  0  0  0  0  0  0  0
LAUREL    NO2+NO3    46  0  0  0  0  0  0  0  0  0
LAUREL    SS         47  0  0  0  0  0  0  0  0  0
LAUREL    TP         48  0  0  0  0  0  0  0  0  0
SCHNEIDERSDO         49  0  0  0  0  0  0  0  0  0
SCHNEIDERSBOD        50  0  0  0  0  0  0  0  0  0
SCHNEIDERSNOD        51  0  0  0  0  0  0  0  0  0
SCHNEIDERSNO2+NO3    52  0  0  0  0  0  0  0  0  0
SCHNEIDERSSS         53  0  0  0  0  0  0  0  0  0
SCHNEIDERSTP         54  0  0  0  0  0  0  0  0  0
SPEED RIVEDO         55  0  0  0  0  0  0  0  0  0
SPEED RIVEBOD        56  0  0  0  0  0  0  0  0  0
SPEED RIVENOD        57  0  0  0  0  0  0  0  0  0
SPEED RIVENO2+NO3    58  0  0  0  0  0  0  0  0  0
SPEED RIVESS         59  0  0  0  0  0  0  0  0  0
SPEED RIVETP         60  0  0  0  0  0  0  0  0  0
ERAMOSA   DO         61  0  0  0  0  0  0  0  0  0
ERAMOSA   BOD        62  0  0  0  0  0  0  0  0  0
ERAMOSA   NOD        63  0  0  0  0  0  0  0  0  0
ERAMOSA   NO2+NO3    64  0  0  0  0  0  0  0  0  0
ERAMOSA   SS         65  0  0  0  0  0  0  0  0  0
ERAMOSA   TP         66  0  0  0  0  0  0  0  0  0
SMITH CREEDO         67  0  0  0  0  0  0  0  0  0
SMITH CREEBOD        68  0  0  0  0  0  0  0  0  0
SMITH CREENOD        69  0  0  0  0  0  0  0  0  0
SMITH CREENO2+NO3    70  0  0  0  0  0  0  0  0  0
SMITH CREESS         71  0  0  0  0  0  0  0  0  0
SMITH CREETP         72  0  0  0  0  0  0  0  0  0
NITH RIVERDO         73  0  0  0  0  0  0  0  0  0
```

The map for water quality distributions needs to be updated to include 6 additional rows (i.e. identical to above) for each month of the simulation. In this example, only the first month is shown.

Step 4: Modify PDFMOD

This file (PDFMOD) contains one row for each boundary and one column for each water quality parameter. Insert an extra row as shown below for Smith Creek. This row allows you to alter the probability distribution for each water quality parameter (e.g., to simulate a 20% reduction in TP from Smith Creek, the last value in the row would be set equal to -0.2). Each value in the probability distribution for TP for Smith Creek will then be multiplied by 0.8 (i.e., 1 – 0.2).



Once you have made the changes described above, the model is ready to run with the new tributary included.

How to Add a New WWTP to GRSM

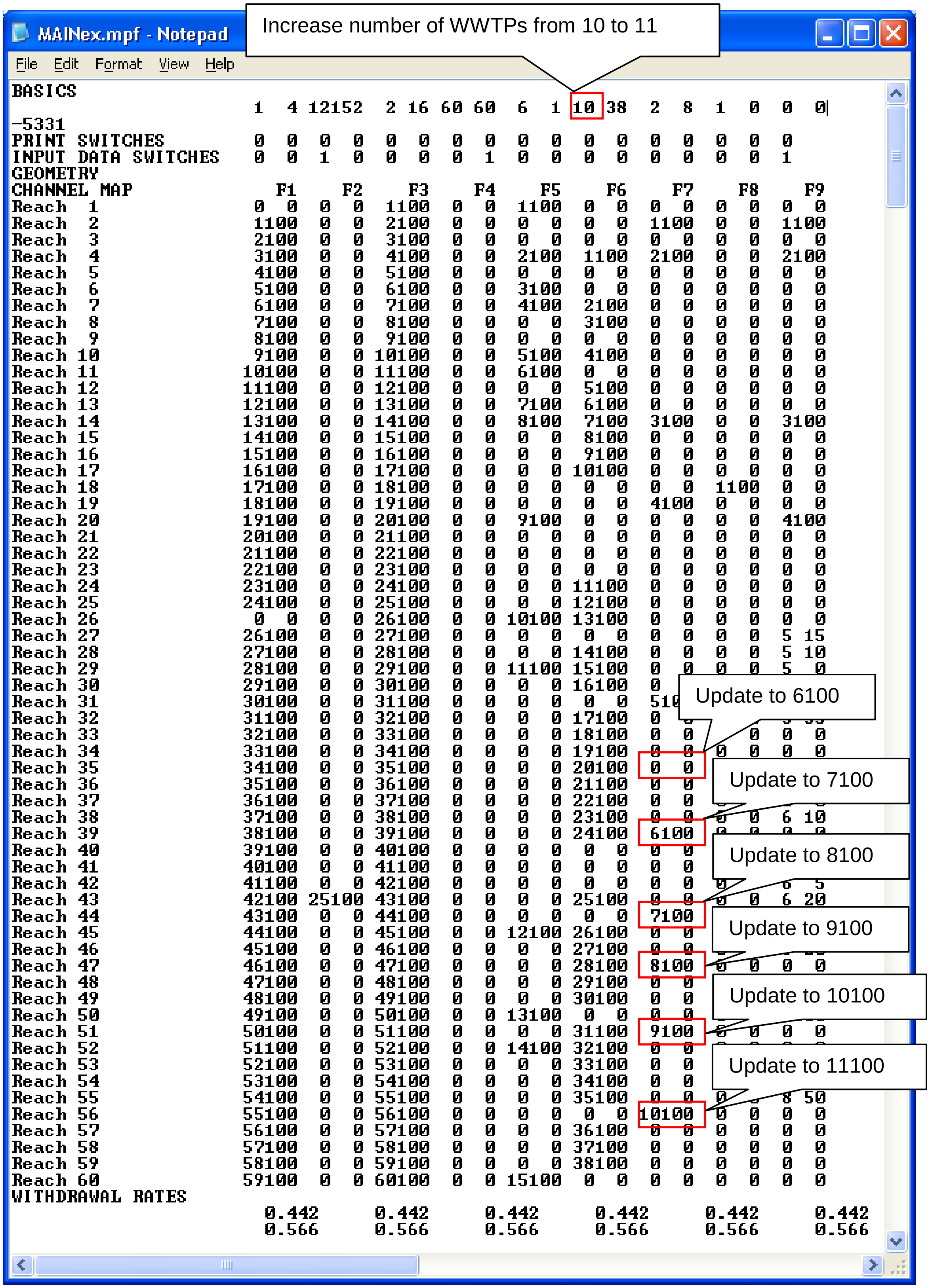
The following information is required to add a WWTP (i.e. point source) to GRSM:

- Daily average WWTP flows for the period of simulation
- Effluent quality data to develop the probability distributions
- The reach where the WWTP enters into the model domain

The steps to set up the input files to include a new WWTP are similar to the steps described above for a new tributary. The example input files included with the model are currently set up to simulate 10 WWTPs. The following section describes how to add a new WWTP called Smithville to GRSM entering at Reach 35.

Step 1: Modify MAINFILE

The MAINFILE needs to be updated in two locations. First, increase the number of WWTPs in the BASICS block. Then modify the GEOMETRY block to show the new WWTP entering at Reach 35. The figure below shows the sections of MAINFILE that need to be updated. The new WWTP is now the sixth point source and subsequent WWTPs are re-numbered to maintain sequential order.



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File Edit Format View Help

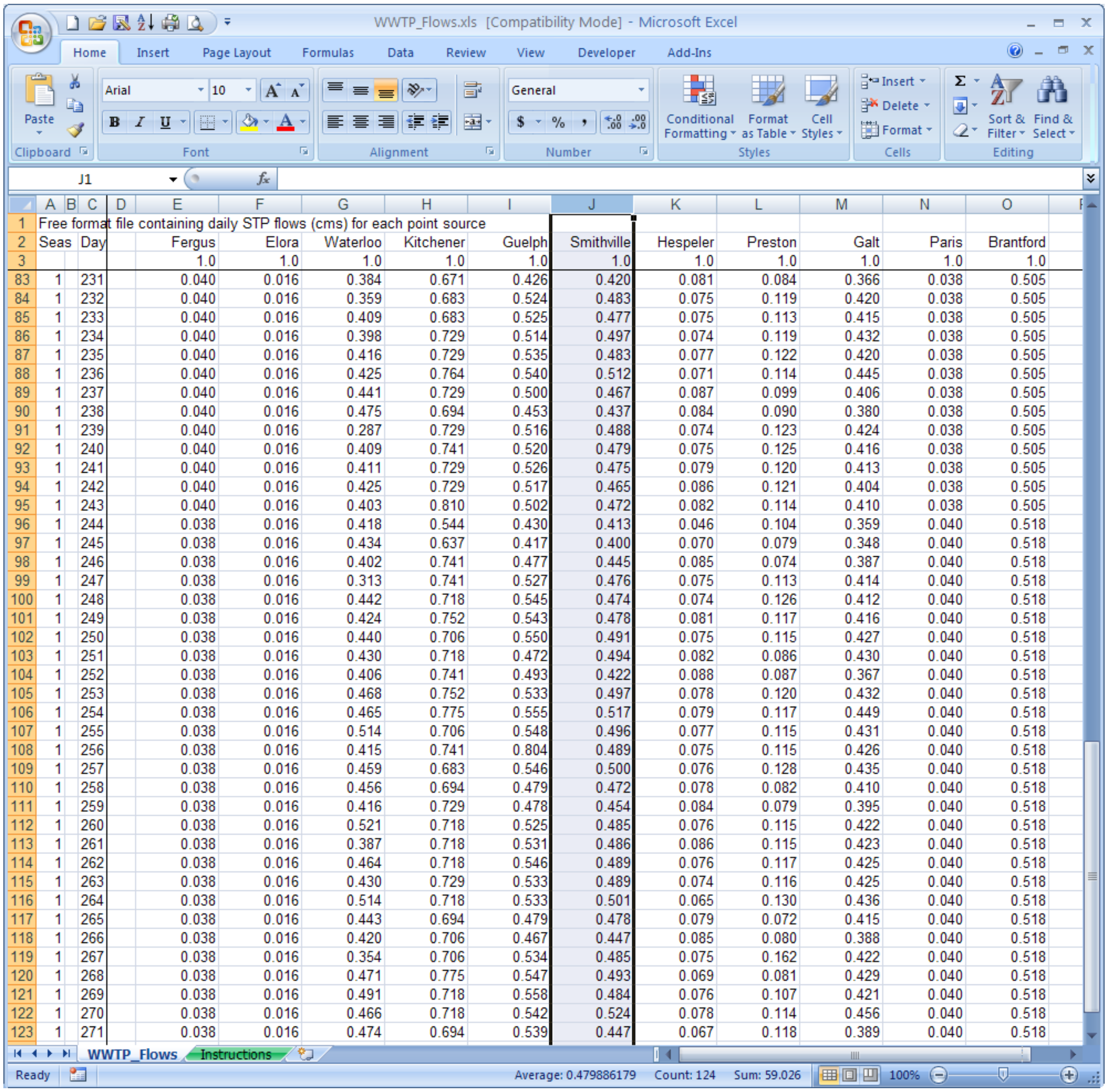
```
BASICS
                         1   4 12152   2  16  60  60   6   1  10  38   2   8   1   0   0   0
-5331
PRINT SWITCHES           0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
INPUT DATA SWITCHES      0   0   1   0   0   0   0   1   0   0   0   0   0   0   0   0   1
GEOMETRY
CHANNEL MAP                 F1      F2      F3      F4      F5      F6      F7      F8      F9
Reach  1                 0   0   0   0  1100   0   0  1100   0   0   0   0   0   0   0   0
Reach  2              1100   0   0  2100   0   0   0   0   0   0  1100   0   0  1100
Reach  3              2100   0   0  3100   0   0   0   0   0   0   0   0   0   0   0   0
Reach  4              3100   0   0  4100   0   0  2100  1100  2100   0   0  2100
Reach  5              4100   0   0  5100   0   0   0   0   0   0   0   0   0   0   0   0
Reach  6              5100   0   0  6100   0   0  3100   0   0   0   0   0   0   0   0
Reach  7              6100   0   0  7100   0   0  4100  2100   0   0   0   0   0   0
Reach  8              7100   0   0  8100   0   0   0   0  3100   0   0   0   0   0   0
Reach  9              8100   0   0  9100   0   0   0   0   0   0   0   0   0   0   0   0
Reach 10              9100   0   0 10100   0   0  5100  4100   0   0   0   0   0   0
Reach 11             10100   0   0 11100   0   0  6100   0   0   0   0   0   0   0   0
Reach 12             11100   0   0 12100   0   0   0   0  5100   0   0   0   0   0   0
Reach 13             12100   0   0 13100   0   0  7100  6100   0   0   0   0   0   0
Reach 14             13100   0   0 14100   0   0  8100  7100  3100   0   0  3100
Reach 15             14100   0   0 15100   0   0   0   0  8100   0   0   0   0   0   0
Reach 16             15100   0   0 16100   0   0   0   0  9100   0   0   0   0   0   0
Reach 17             16100   0   0 17100   0   0   0   0 10100   0   0   0   0   0   0
Reach 18             17100   0   0 18100   0   0   0   0   0   0   0   0  1100   0   0
Reach 19             18100   0   0 19100   0   0   0   0   0   0  4100   0   0   0   0
Reach 20             19100   0   0 20100   0   0  9100   0   0   0   0   0   0  4100
Reach 21             20100   0   0 21100   0   0   0   0   0   0   0   0   0   0   0   0
Reach 22             21100   0   0 22100   0   0   0   0   0   0   0   0   0   0   0   0
Reach 23             22100   0   0 23100   0   0   0   0   0   0   0   0   0   0   0   0
Reach 24             23100   0   0 24100   0   0   0   0 11100   0   0   0   0   0   0
Reach 25             24100   0   0 25100   0   0   0   0 12100   0   0   0   0   0   0
Reach 26                 0   0   0   0 26100   0   0 10100 13100   0   0   0   0   0   0
Reach 27             26100   0   0 27100   0   0   0   0   0   0   0   0   0   0   5  15
Reach 28             27100   0   0 28100   0   0   0   0 14100   0   0   0   0   5  10
Reach 29             28100   0   0 29100   0   0 11100 15100   0   0   0   0   5   0
Reach 30             29100   0   0 30100   0   0   0   0 16100   0 [illegible]
Reach 31             30100   0   0 31100   0   0   0   0   0   0  510[illegible]
Reach 32             31100   0   0 32100   0   0   0   0 17100   0 [illegible]
Reach 33             32100   0   0 33100   0   0   0   0 18100   0   0 [illegible]   0   0   0
Reach 34             33100   0   0 34100   0   0   0   0 19100   0   0   0   0   0   0
Reach 35             34100   0   0 35100   0   0   0   0 20100   0   0 [illegible]
Reach 36             35100   0   0 36100   0   0   0   0 21100   0   0 [illegible]
Reach 37             36100   0   0 37100   0   0   0   0 22100   0   0 [illegible]
Reach 38             37100   0   0 38100   0   0   0   0 23100   0   0   0   0   6  10
Reach 39             38100   0   0 39100   0   0   0   0 24100  6100 [illegible]
Reach 40             39100   0   0 40100   0   0   0   0   0   0   0   0 [illegible]
Reach 41             40100   0   0 41100   0   0   0   0   0   0   0   0 [illegible]
Reach 42             41100   0   0 42100   0   0   0   0   0   0   0   0   0 [illegible]   6   5
Reach 43             42100 25100   0 43100   0   0   0   0 25100   0   0   0   0   6  20
Reach 44             43100   0   0 44100   0   0   0   0   0   0  7100 [illegible]
Reach 45             44100   0   0 45100   0   0 12100 26100   0   0 [illegible]
Reach 46             45100   0   0 46100   0   0   0   0 27100   0   0 [illegible]
Reach 47             46100   0   0 47100   0   0   0   0 28100  8100   0   0   0   0
Reach 48             47100   0   0 48100   0   0   0   0 29100   0   0 [illegible]
Reach 49             48100   0   0 49100   0   0   0   0 30100   0   0 [illegible]
Reach 50             49100   0   0 50100   0   0 13100   0   0   0   0 [illegible]
Reach 51             50100   0   0 51100   0   0   0   0 31100  9100   0   0   0   0
Reach 52             51100   0   0 52100   0   0 14100 32100   0   0 [illegible]
Reach 53             52100   0   0 53100   0   0   0   0 33100   0   0 [illegible]
Reach 54             53100   0   0 54100   0   0   0   0 34100   0   0 [illegible]
Reach 55             54100   0   0 55100   0   0   0   0 35100   0   0   0 [illegible]   8  50
Reach 56             55100   0   0 56100   0   0   0   0   0   0 10100   0   0   0   0
Reach 57             56100   0   0 57100   0   0   0   0 36100   0   0   0   0   0   0
Reach 58             57100   0   0 58100   0   0   0   0 37100   0   0   0   0   0   0
Reach 59             58100   0   0 59100   0   0   0   0 38100   0   0   0   0   0   0
Reach 60             59100   0   0 60100   0   0 15100   0   0   0   0   0   0   0   0
WITHDRAWAL RATES
                           0.442      0.442      0.442      0.442      0.442      0.442
                           0.566      0.566      0.566      0.566      0.566      0.566
```

Appendix A

Step 2: Modify STP_FLOW_FILE

Update the STP_FLOW_FILE to include daily average WWTP effluent flows in cubic metres per second. The template called WWTP_flows.xls can be used to easily insert the required data into the input file as shown below.

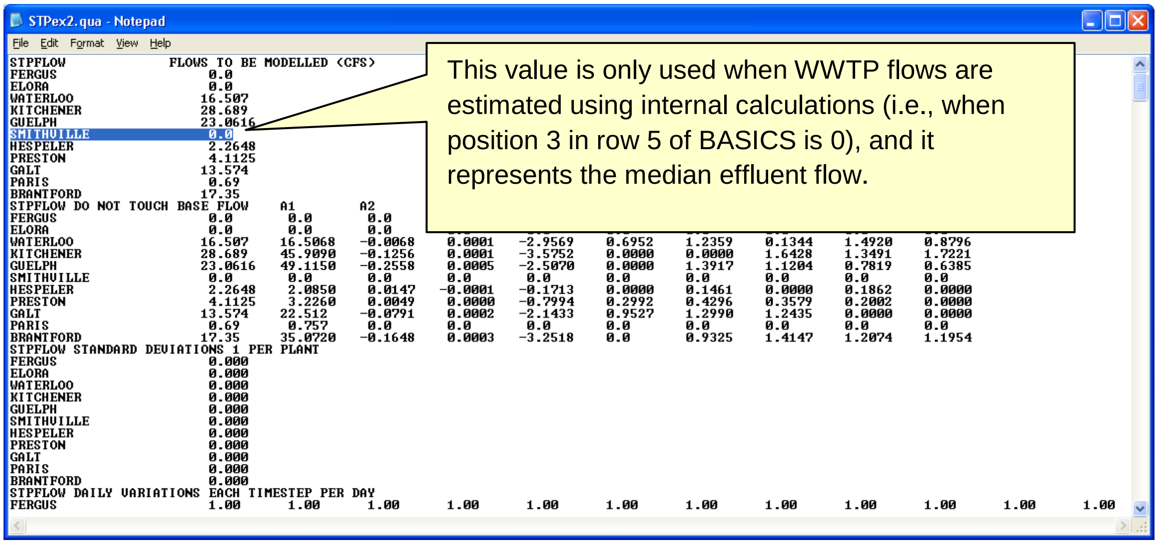
Based on the sequential order of the GEOMETRY block, flow data for the Smithville WWTP must appear in the sixth position, between Guelph and Hespeler.

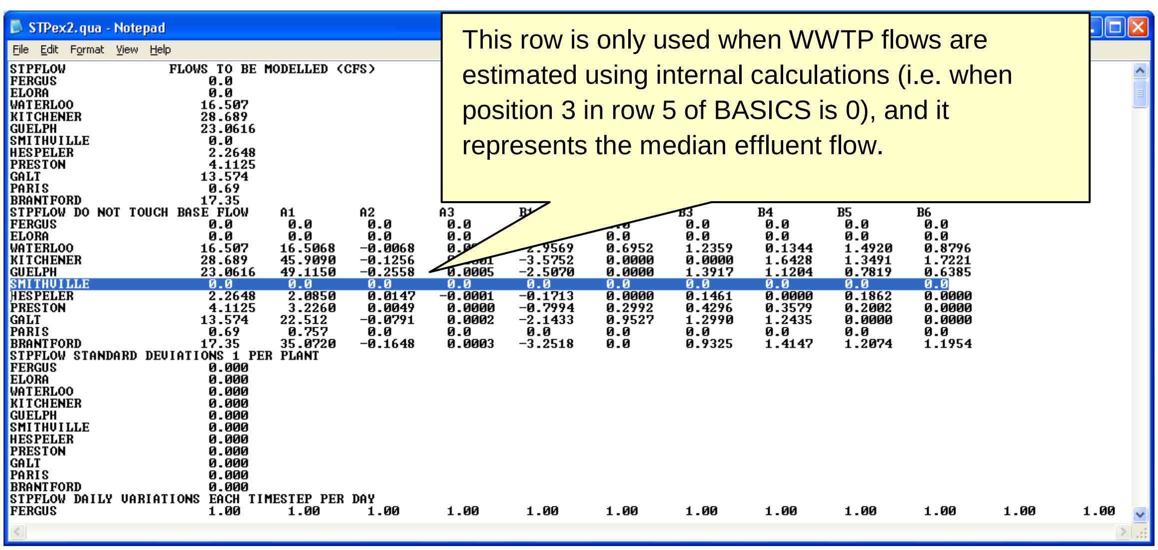


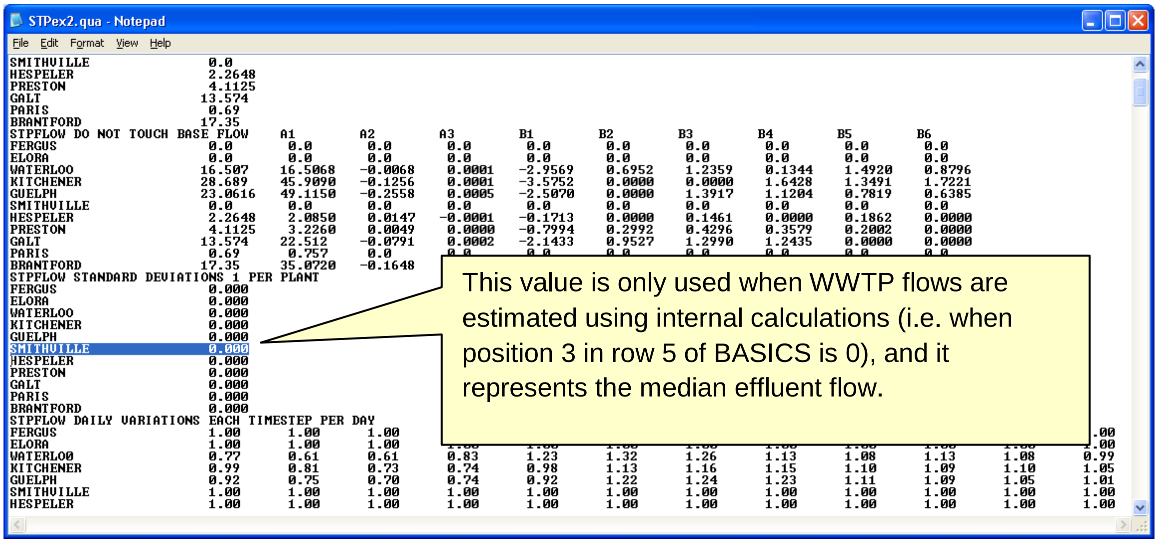
	Seas	Day	Fergus	Elora	Waterloo	Kitchener	Guelph	Smithville	Hespeler	Preston	Galt	Paris	Brantford
3			1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
83	1	231	0.040	0.016	0.384	0.671	0.426	0.420	0.081	0.084	0.366	0.038	0.505
84	1	232	0.040	0.016	0.359	0.683	0.524	0.483	0.075	0.119	0.420	0.038	0.505
85	1	233	0.040	0.016	0.409	0.683	0.525	0.477	0.075	0.113	0.415	0.038	0.505
86	1	234	0.040	0.016	0.398	0.729	0.514	0.497	0.074	0.119	0.432	0.038	0.505
87	1	235	0.040	0.016	0.416	0.729	0.535	0.483	0.077	0.122	0.420	0.038	0.505
88	1	236	0.040	0.016	0.425	0.764	0.540	0.512	0.071	0.114	0.445	0.038	0.505
89	1	237	0.040	0.016	0.441	0.729	0.500	0.467	0.087	0.099	0.406	0.038	0.505
90	1	238	0.040	0.016	0.475	0.694	0.453	0.437	0.084	0.090	0.380	0.038	0.505
91	1	239	0.040	0.016	0.287	0.729	0.516	0.488	0.074	0.123	0.424	0.038	0.505
92	1	240	0.040	0.016	0.409	0.741	0.520	0.479	0.075	0.125	0.416	0.038	0.505
93	1	241	0.040	0.016	0.411	0.729	0.526	0.475	0.079	0.120	0.413	0.038	0.505
94	1	242	0.040	0.016	0.425	0.729	0.517	0.465	0.086	0.121	0.404	0.038	0.505
95	1	243	0.040	0.016	0.403	0.810	0.502	0.472	0.082	0.114	0.410	0.038	0.505
96	1	244	0.038	0.016	0.418	0.544	0.430	0.413	0.046	0.104	0.359	0.040	0.518
97	1	245	0.038	0.016	0.434	0.637	0.417	0.400	0.070	0.079	0.348	0.040	0.518
98	1	246	0.038	0.016	0.402	0.741	0.477	0.445	0.085	0.074	0.387	0.040	0.518
99	1	247	0.038	0.016	0.313	0.741	0.527	0.476	0.075	0.113	0.414	0.040	0.518
100	1	248	0.038	0.016	0.442	0.718	0.545	0.474	0.074	0.126	0.412	0.040	0.518
101	1	249	0.038	0.016	0.424	0.752	0.543	0.478	0.081	0.117	0.416	0.040	0.518
102	1	250	0.038	0.016	0.440	0.706	0.550	0.491	0.075	0.115	0.427	0.040	0.518
103	1	251	0.038	0.016	0.430	0.718	0.472	0.494	0.082	0.086	0.430	0.040	0.518
104	1	252	0.038	0.016	0.406	0.741	0.493	0.422	0.088	0.087	0.367	0.040	0.518
105	1	253	0.038	0.016	0.468	0.752	0.533	0.497	0.078	0.120	0.432	0.040	0.518
106	1	254	0.038	0.016	0.465	0.775	0.555	0.517	0.079	0.117	0.449	0.040	0.518
107	1	255	0.038	0.016	0.514	0.706	0.548	0.496	0.077	0.115	0.431	0.040	0.518
108	1	256	0.038	0.016	0.415	0.741	0.804	0.489	0.075	0.115	0.426	0.040	0.518
109	1	257	0.038	0.016	0.459	0.683	0.546	0.500	0.076	0.128	0.435	0.040	0.518
110	1	258	0.038	0.016	0.456	0.694	0.479	0.472	0.078	0.082	0.410	0.040	0.518
111	1	259	0.038	0.016	0.416	0.729	0.478	0.454	0.084	0.079	0.395	0.040	0.518
112	1	260	0.038	0.016	0.521	0.718	0.525	0.485	0.076	0.115	0.422	0.040	0.518
113	1	261	0.038	0.016	0.387	0.718	0.531	0.486	0.086	0.115	0.423	0.040	0.518
114	1	262	0.038	0.016	0.464	0.718	0.546	0.489	0.076	0.117	0.425	0.040	0.518
115	1	263	0.038	0.016	0.430	0.729	0.533	0.489	0.074	0.116	0.425	0.040	0.518
116	1	264	0.038	0.016	0.514	0.718	0.533	0.501	0.065	0.130	0.436	0.040	0.518
117	1	265	0.038	0.016	0.443	0.694	0.479	0.478	0.079	0.072	0.415	0.040	0.518
118	1	266	0.038	0.016	0.420	0.706	0.467	0.447	0.085	0.080	0.388	0.040	0.518
119	1	267	0.038	0.016	0.354	0.706	0.534	0.485	0.075	0.162	0.422	0.040	0.518
120	1	268	0.038	0.016	0.471	0.775	0.547	0.493	0.069	0.081	0.429	0.040	0.518
121	1	269	0.038	0.016	0.491	0.718	0.558	0.484	0.076	0.107	0.421	0.040	0.518
122	1	270	0.038	0.016	0.466	0.718	0.542	0.524	0.078	0.114	0.456	0.040	0.518
123	1	271	0.038	0.016	0.474	0.694	0.539	0.447	0.067	0.118	0.389	0.040	0.518

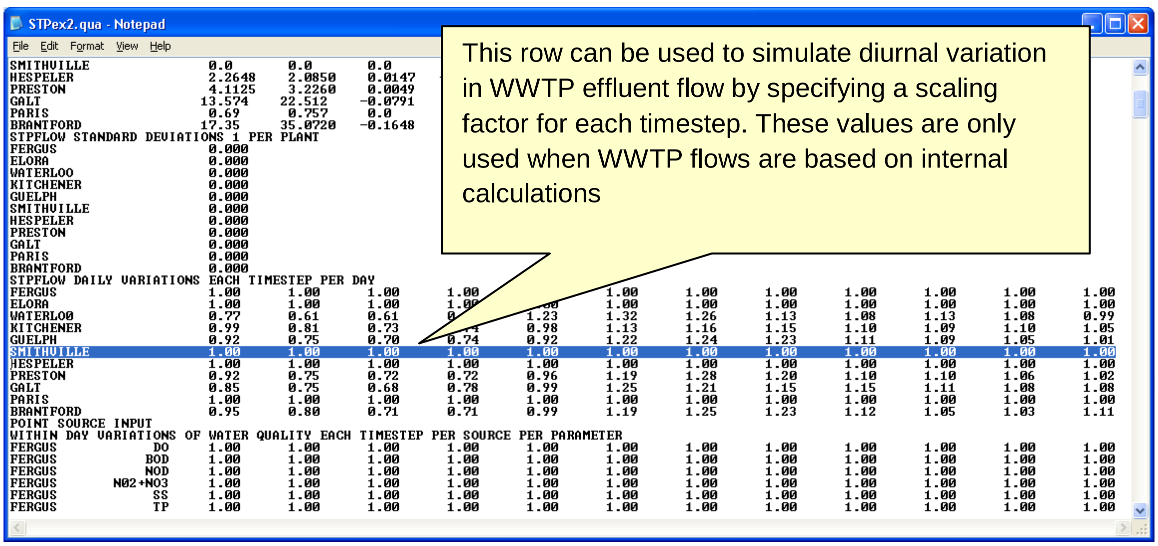
Step 3: Modify STPFLOW

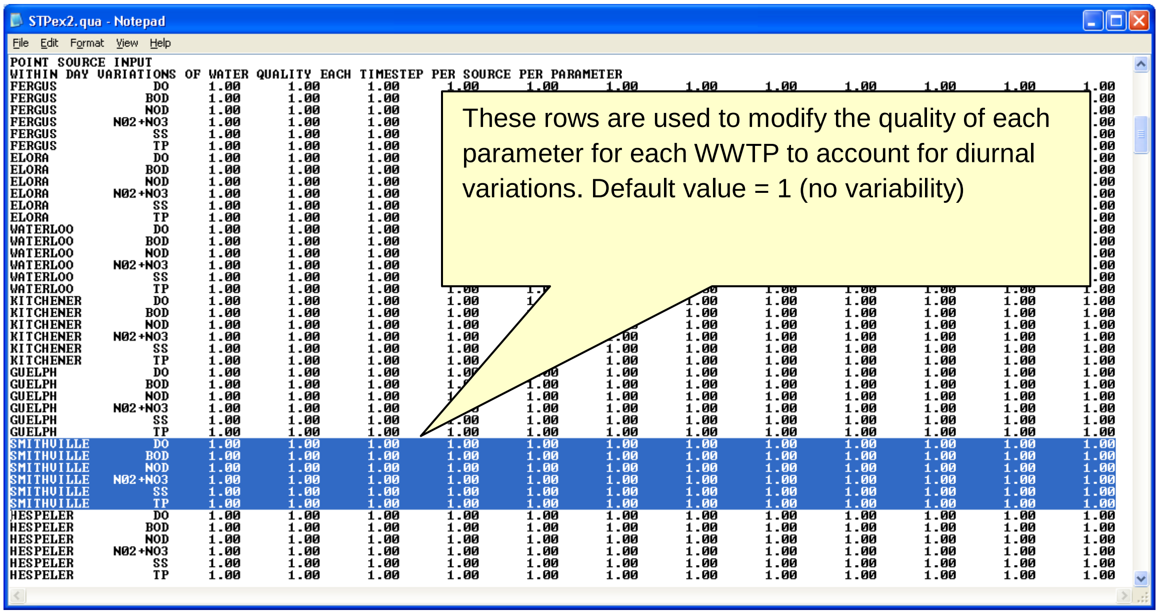
The next step is to update the STPFLOW file to reflect the effluent quality for Smithville WWTP. There are several blocks in the STPFLOW file that have to be modified to include an additional WWTP, even though these blocks are not used in the current model configuration (e.g., the blocks that describe how the flows are estimated using internal calculations need to be modified, even though flows are being read from an external file). The screen shots below show the sections that need to be updated.

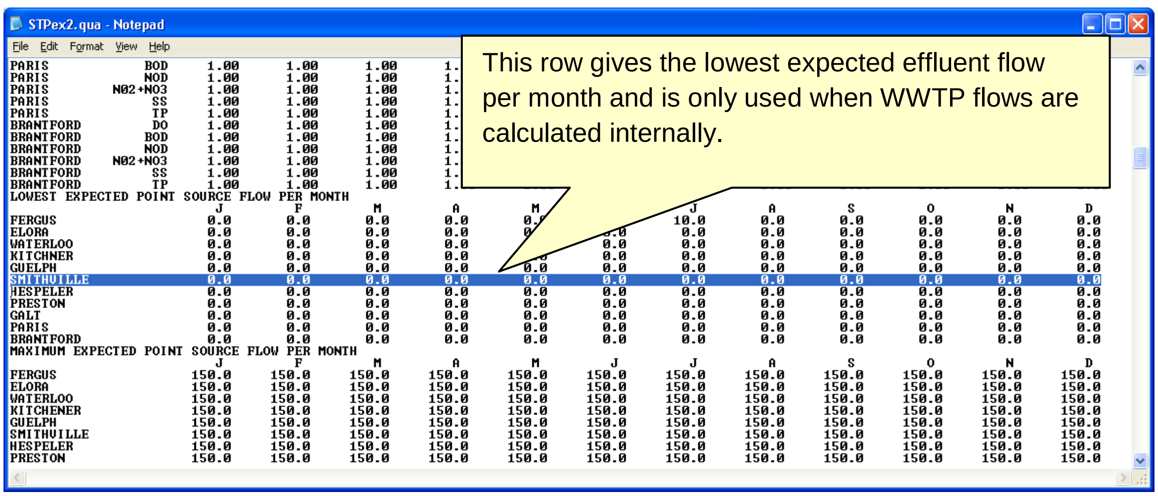


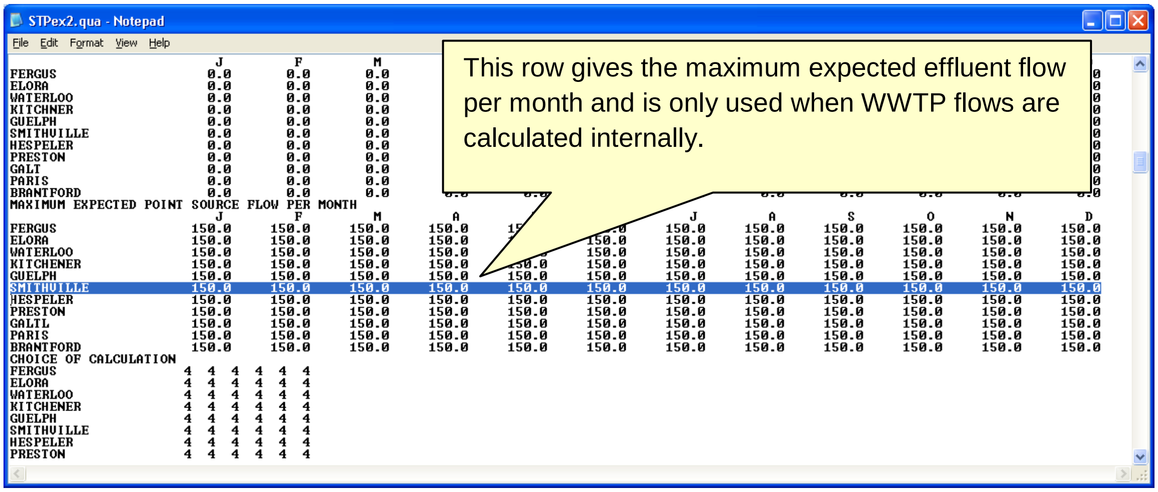


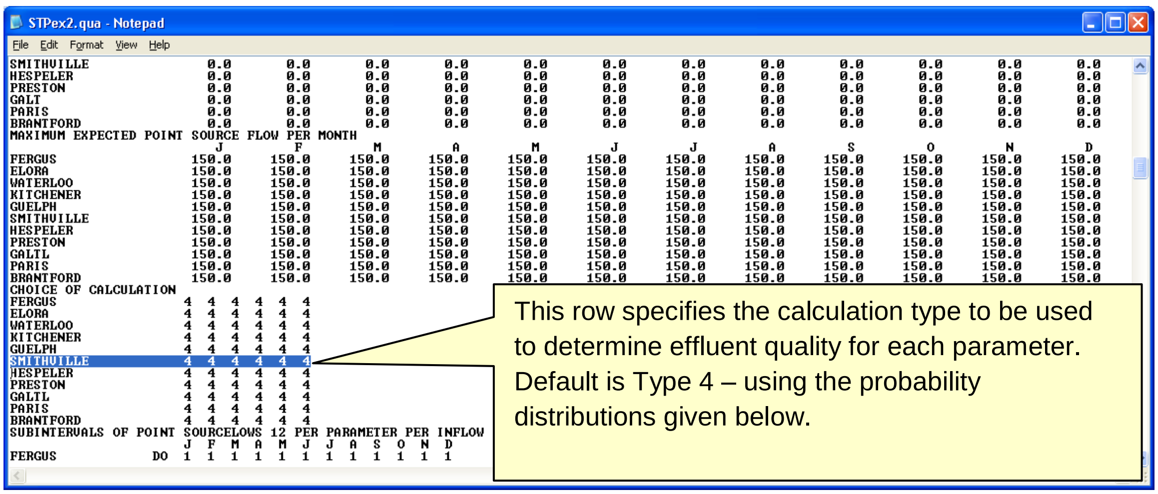

STPex2.qua - Notepad
This value is only used when WWTP flows are estimated using internal calculations (i.e. when position 3 in row 5 of BASICS is 0), and it represents the median effluent flow.

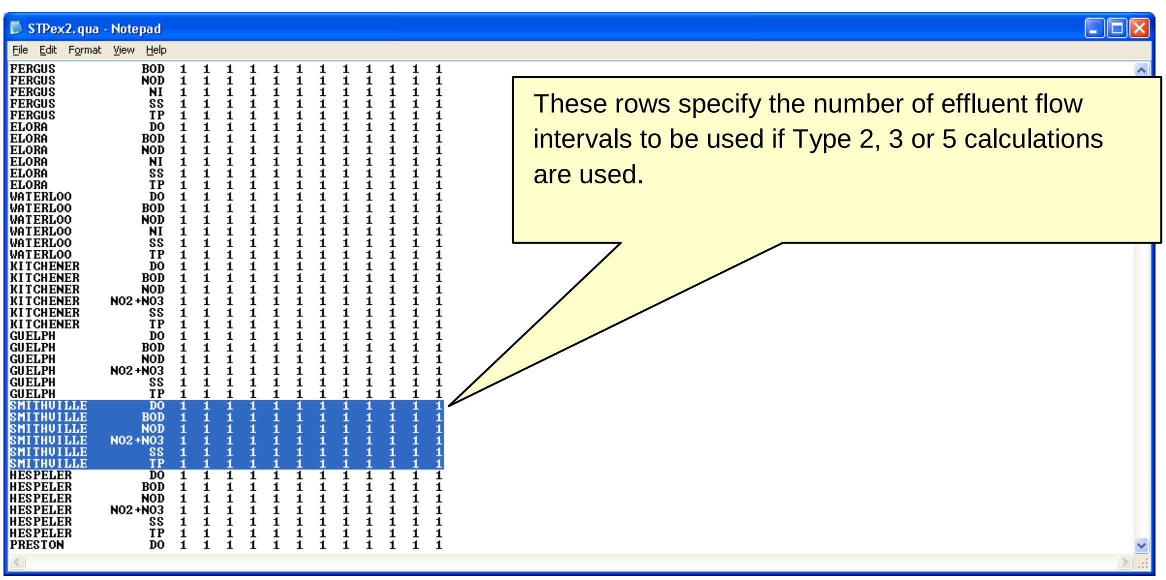

STPex2.qua - Notepad
This row can be used to simulate diurnal variation in WWTP effluent flow by specifying a scaling factor for each timestep. These values are only used when WWTP flows are based on internal calculations


STPex2.qua - Notepad
File Edit Format View Help
POINT SOURCE INPUT
WITHIN DAY VARIATIONS OF WATER QUALITY EACH TIMESTEP PER SOURCE PER PARAMETER
These rows are used to modify the quality of each parameter for each WWTP to account for diurnal variations. Default value = 1 (no variability)


STPex2.qua - Notepad
File Edit Format View Help
This row gives the lowest expected effluent flow per month and is only used when WWTP flows are calculated internally.
LOWEST EXPECTED POINT SOURCE FLOW PER MONTH
MAXIMUM EXPECTED POINT SOURCE FLOW PER MONTH

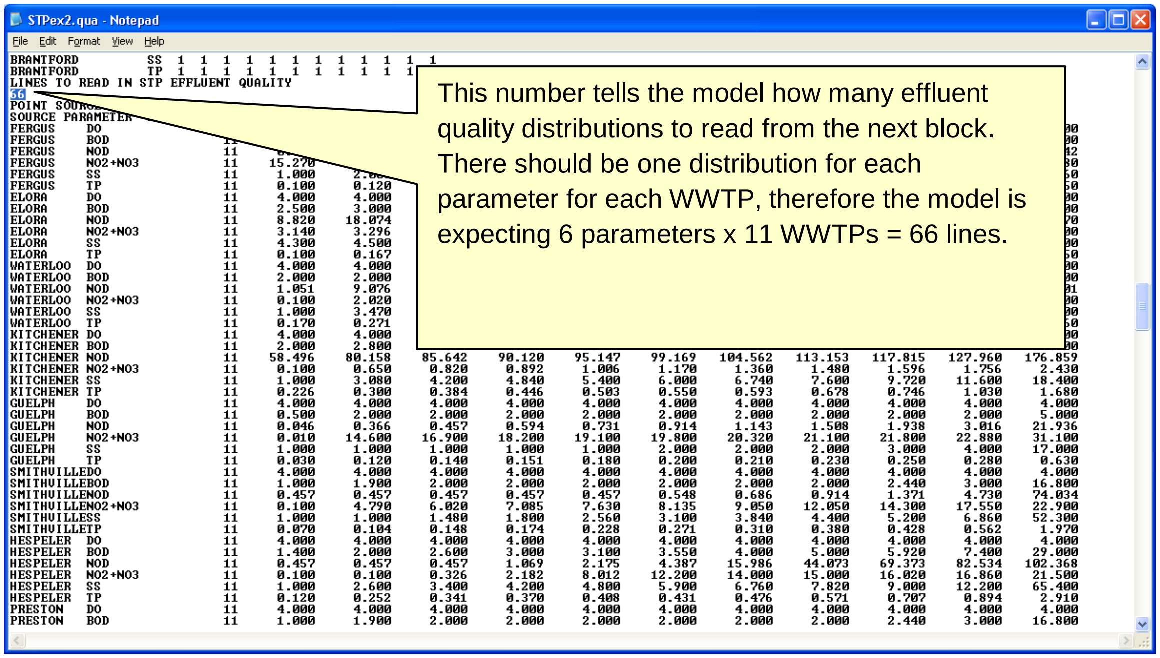

STPex2.qua - Notepad
MAXIMUM EXPECTED POINT SOURCE FLOW PER MONTH
CHOICE OF CALCULATION
This row gives the maximum expected effluent flow per month and is only used when WWTP flows are calculated internally.

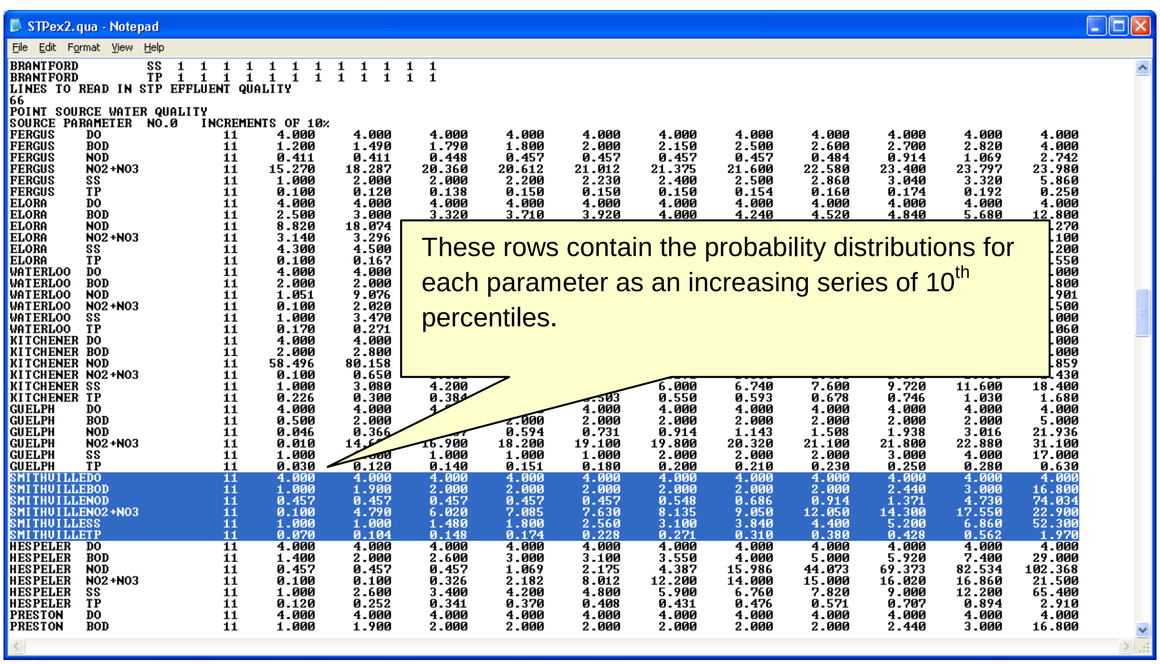

STPex2.qua - Notepad
MAXIMUM EXPECTED POINT SOURCE FLOW PER MONTH
CHOICE OF CALCULATION
SUBINTERVALS OF POINT SOURCEFLOWS 12 PER PARAMETER PER INFLOW
This row specifies the calculation type to be used to determine effluent quality for each parameter. Default is Type 4 – using the probability distributions given below.


STPex2.qua - Notepad
These rows specify the number of effluent flow intervals to be used if Type 2, 3 or 5 calculations are used.

Appendix A

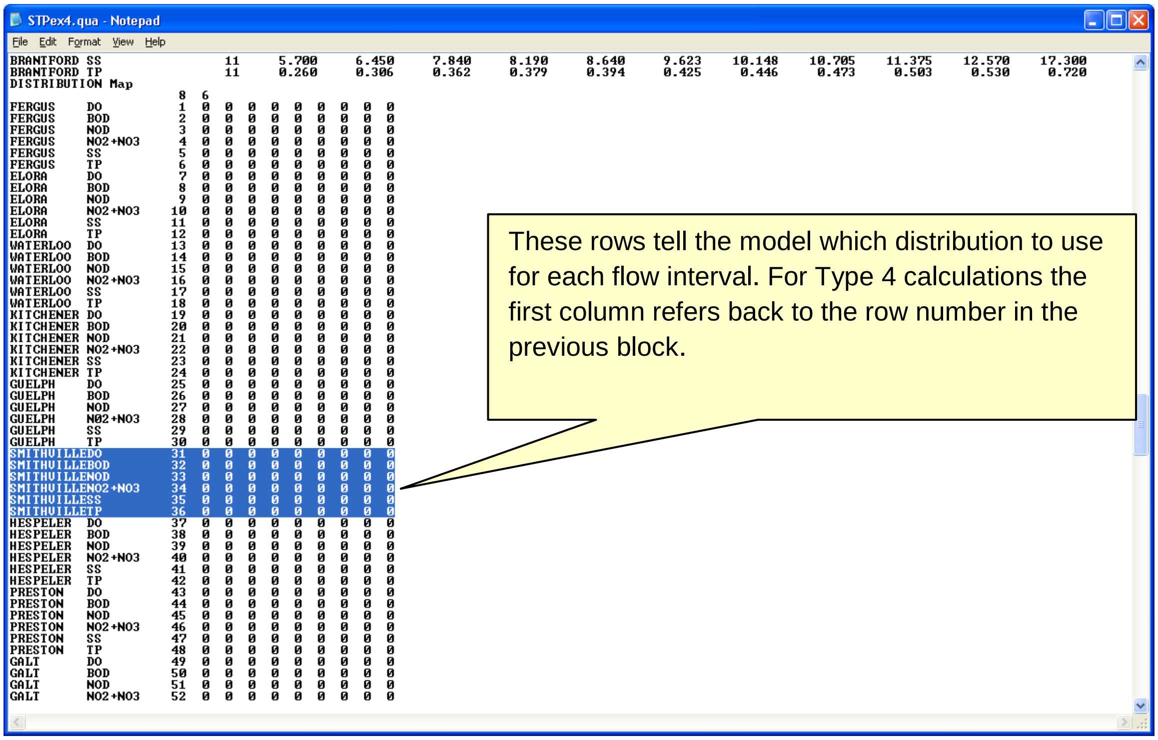
WWTP effluent quality is current modeled using Type 4, which assumes that the effluent quality can be described by a probability distribution for each parameter. The follow screen shots show the section of STPFLOW that need to be updated to reflect these distributions for the Smithville WWTP. These distributions should be based on representative sampling of the effluent and are input into the model as an increasing sequence of 10th percentiles.





Appendix A

The following screen shot shows the map of effluent quality distributions that tells the model which distribution in the previous block to use for effluent quality calculations. For each WWTP, there is one row for each parameter and 10 columns for the flow intervals. For Type 4 calculations, there is only one flow interval and therefore the first column must be populated with the row number of the probability distribution in the previous block. For example, the distribution for dissolved oxygen for Smithville is contained on row 31 of the previous block. If the calculation method is Type 2, 3 or 5 where there are multiple flow intervals, this map must contain the row number of the distribution to be used for each flow interval.

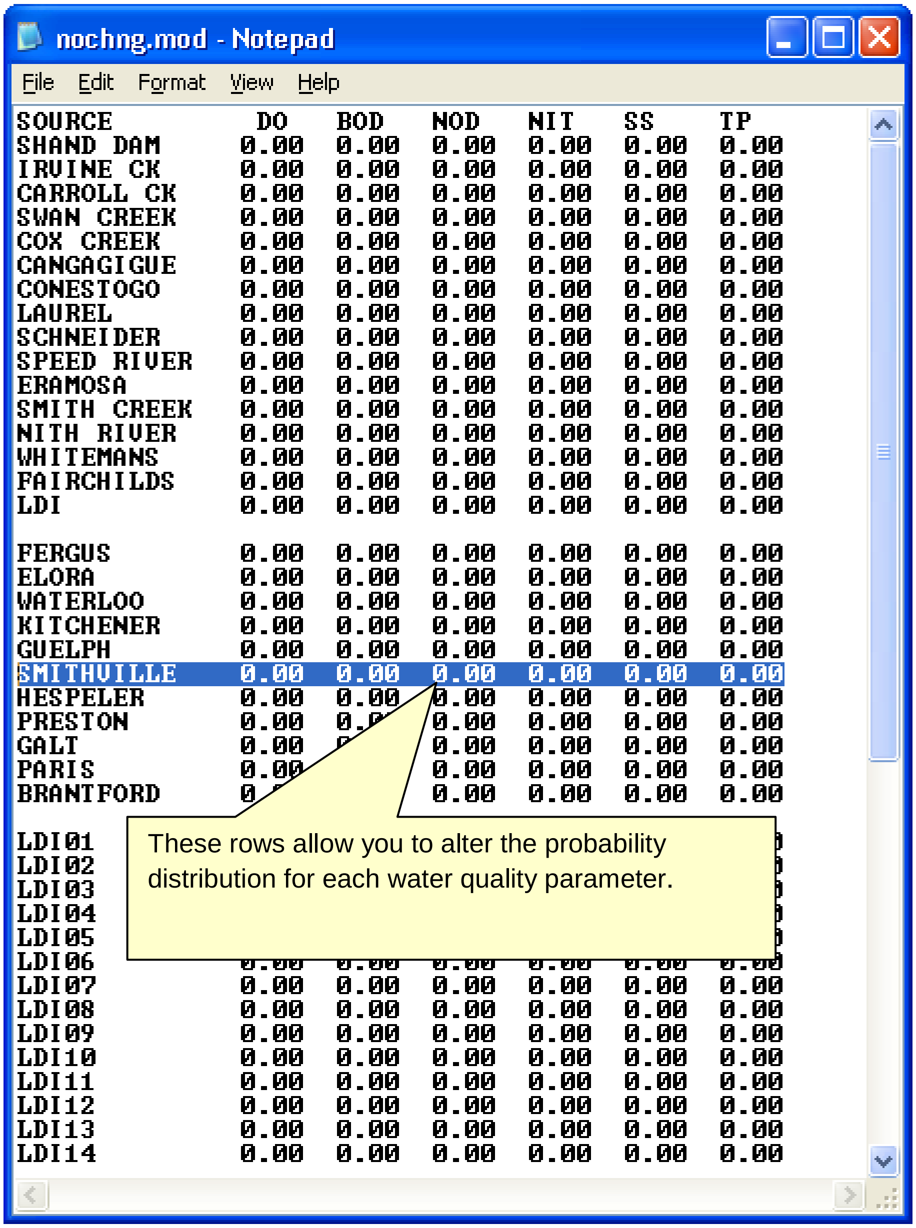


```
STPex4.qua - Notepad
File  Edit  Format  View  Help
BRANTFORD SS            11     5.700     6.450     7.840     8.190     8.640     9.623    10.148    10.705    11.375    12.570    17.300
BRANTFORD TP            11     0.260     0.306     0.362     0.379     0.394     0.425     0.446     0.473     0.503     0.530     0.720
DISTRIBUTION Map
                      8  6
FERGUS    DO          1  0  0  0  0  0  0  0  0  0
FERGUS    BOD         2  0  0  0  0  0  0  0  0  0
FERGUS    NOD         3  0  0  0  0  0  0  0  0  0
FERGUS    NO2+NO3     4  0  0  0  0  0  0  0  0  0
FERGUS    SS          5  0  0  0  0  0  0  0  0  0
FERGUS    TP          6  0  0  0  0  0  0  0  0  0
ELORA     DO          7  0  0  0  0  0  0  0  0  0
ELORA     BOD         8  0  0  0  0  0  0  0  0  0
ELORA     NOD         9  0  0  0  0  0  0  0  0  0
ELORA     NO2+NO3    10  0  0  0  0  0  0  0  0  0
ELORA     SS         11  0  0  0  0  0  0  0  0  0
ELORA     TP         12  0  0  0  0  0  0  0  0  0
WATERLOO  DO         13  0  0  0  0  0  0  0  0  0
WATERLOO  BOD        14  0  0  0  0  0  0  0  0  0
WATERLOO  NOD        15  0  0  0  0  0  0  0  0  0
WATERLOO  NO2+NO3    16  0  0  0  0  0  0  0  0  0
WATERLOO  SS         17  0  0  0  0  0  0  0  0  0
WATERLOO  TP         18  0  0  0  0  0  0  0  0  0
KITCHENER DO         19  0  0  0  0  0  0  0  0  0
KITCHENER BOD        20  0  0  0  0  0  0  0  0  0
KITCHENER NOD        21  0  0  0  0  0  0  0  0  0
KITCHENER NO2+NO3    22  0  0  0  0  0  0  0  0  0
KITCHENER SS         23  0  0  0  0  0  0  0  0  0
KITCHENER TP         24  0  0  0  0  0  0  0  0  0
GUELPH    DO         25  0  0  0  0  0  0  0  0  0
GUELPH    BOD        26  0  0  0  0  0  0  0  0  0
GUELPH    NOD        27  0  0  0  0  0  0  0  0  0
GUELPH    N02+NO3    28  0  0  0  0  0  0  0  0  0
GUELPH    SS         29  0  0  0  0  0  0  0  0  0
GUELPH    TP         30  0  0  0  0  0  0  0  0  0
SMITHVILLEDO         31  0  0  0  0  0  0  0  0  0
SMITHVILLEBOD        32  0  0  0  0  0  0  0  0  0
SMITHVILLENOD        33  0  0  0  0  0  0  0  0  0
SMITHVILLENO2+NO3    34  0  0  0  0  0  0  0  0  0
SMITHVILLESS         35  0  0  0  0  0  0  0  0  0
SMITHVILLETP         36  0  0  0  0  0  0  0  0  0
HESPELER  DO         37  0  0  0  0  0  0  0  0  0
HESPELER  BOD        38  0  0  0  0  0  0  0  0  0
HESPELER  NOD        39  0  0  0  0  0  0  0  0  0
HESPELER  NO2+NO3    40  0  0  0  0  0  0  0  0  0
HESPELER  SS         41  0  0  0  0  0  0  0  0  0
HESPELER  TP         42  0  0  0  0  0  0  0  0  0
PRESTON   DO         43  0  0  0  0  0  0  0  0  0
PRESTON   BOD        44  0  0  0  0  0  0  0  0  0
PRESTON   NOD        45  0  0  0  0  0  0  0  0  0
PRESTON   NO2+NO3    46  0  0  0  0  0  0  0  0  0
PRESTON   SS         47  0  0  0  0  0  0  0  0  0
PRESTON   TP         48  0  0  0  0  0  0  0  0  0
GALT      DO         49  0  0  0  0  0  0  0  0  0
GALT      BOD        50  0  0  0  0  0  0  0  0  0
GALT      NOD        51  0  0  0  0  0  0  0  0  0
GALT      NO2+NO3    52  0  0  0  0  0  0  0  0  0
```


The map for water quality distributions needs to be updated to include 6 additional rows (i.e. identical to above) for each month of the simulation. In this example, only the first month is shown.

Step 4: Modify PDFMOD

The last file that needs to be update is called PDFMOD. This file contains one row for each WWTP and one column for each water quality parameter. An extra row must be inserted as shown below for the Smithville WWTP. This row allows you to alter the probability distribution for each water quality parameter (e.g., to simulate a 70% reduction in BOD from the Smithville WWTP, the second value in the row would be set equal to -0.7). Each value in the probability distribution for BOD for Smithville will then be multiplied by 0.3 (i.e. 1 – 0.7).



SOURCE	DO	BOD	NOD	NIT	SS	TP
SHAND DAM	0.00	0.00	0.00	0.00	0.00	0.00
IRVINE CK	0.00	0.00	0.00	0.00	0.00	0.00
CARROLL CK	0.00	0.00	0.00	0.00	0.00	0.00
SWAN CREEK	0.00	0.00	0.00	0.00	0.00	0.00
COX CREEK	0.00	0.00	0.00	0.00	0.00	0.00
CANGAGIGUE	0.00	0.00	0.00	0.00	0.00	0.00
CONESTOGO	0.00	0.00	0.00	0.00	0.00	0.00
LAUREL	0.00	0.00	0.00	0.00	0.00	0.00
SCHNEIDER	0.00	0.00	0.00	0.00	0.00	0.00
SPEED RIVER	0.00	0.00	0.00	0.00	0.00	0.00
ERAMOSA	0.00	0.00	0.00	0.00	0.00	0.00
SMITH CREEK	0.00	0.00	0.00	0.00	0.00	0.00
NITH RIVER	0.00	0.00	0.00	0.00	0.00	0.00
WHITEMANS	0.00	0.00	0.00	0.00	0.00	0.00
FAIRCHILDS	0.00	0.00	0.00	0.00	0.00	0.00
LDI	0.00	0.00	0.00	0.00	0.00	0.00
FERGUS	0.00	0.00	0.00	0.00	0.00	0.00
ELORA	0.00	0.00	0.00	0.00	0.00	0.00
WATERLOO	0.00	0.00	0.00	0.00	0.00	0.00
KITCHENER	0.00	0.00	0.00	0.00	0.00	0.00
GUELPH	0.00	0.00	0.00	0.00	0.00	0.00
SMITHVILLE	0.00	0.00	0.00	0.00	0.00	0.00
HESPELER	0.00	0.00	0.00	0.00	0.00	0.00
PRESTON	0.00	0.0[illegible]	0.00	0.00	0.00	0.00
GALT	0.00	[illegible]	0.00	0.00	0.00	0.00
PARIS	0.00	[illegible]	0.00	0.00	0.00	0.00
BRANTFORD	0[illegible]	[illegible]	0.00	0.00	0.00	0.00
LDI01	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
LDI02	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
LDI03	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
LDI04	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
LDI05	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
LDI06	0.00	0.00	0.00	0.00	0.00	0.00
LDI07	0.00	0.00	0.00	0.00	0.00	0.00
LDI08	0.00	0.00	0.00	0.00	0.00	0.00
LDI09	0.00	0.00	0.00	0.00	0.00	0.00
LDI10	0.00	0.00	0.00	0.00	0.00	0.00
LDI11	0.00	0.00	0.00	0.00	0.00	0.00
LDI12	0.00	0.00	0.00	0.00	0.00	0.00
LDI13	0.00	0.00	0.00	0.00	0.00	0.00
LDI14	0.00	0.00	0.00	0.00	0.00	0.00

How to Modify WWTP Flows and Effluent Quality to Simulate Various Scenarios

A typical application of GRSM involves modifying the input files to simulate various possible future scenarios to estimate potential water quality impacts associated with population growth (e.g. higher effluent flows) and/or treatment upgrades (e.g. reduced concentrations in effluent). The following example shows you how to modify the input files to create scenarios.

Each scenario will be assigned a run number, which allows the output files to be distinguished from one another. The base case will be the output from the model prior to making any changes to effluent flow or quality and this will be designated Run 0. Scenario 1 will be Run 1 and likewise, Scenario 2 described below will be Run 2. When the input files are being modified for each scenario, it is useful to save each modified input file under a new name and keep a log of the input files used to create each run for audit purposes.

Scenario 1: Increase effluent flow from Smithville WWTP by 50%

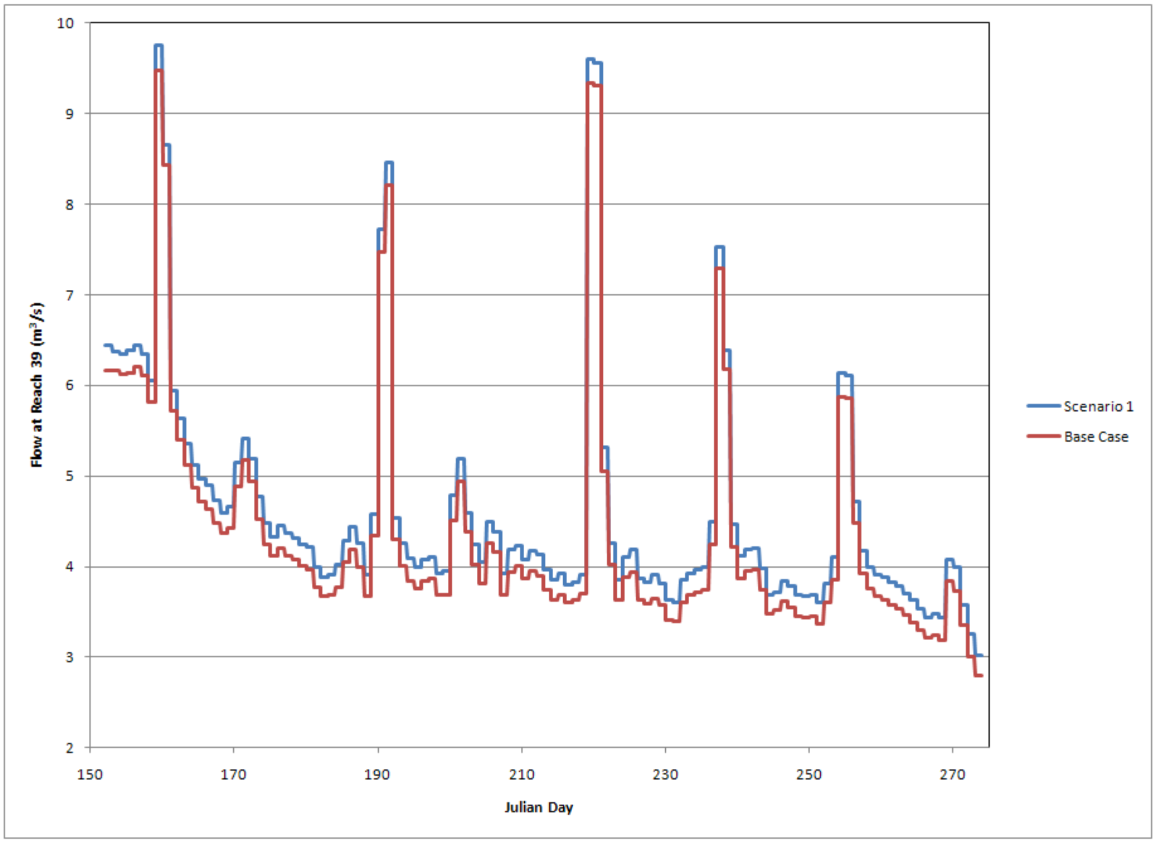
The WWTP_Qual.xls template can be used to create a new input file with an updated flow series for the Smithville WWTP reflecting higher values. Alternatively, there is a scaling factor in the STP_FLOW_FILE that can be modified to simulate a 50% increase in effluent flow from the Smithville WWTP. The following screen shot shows the scaling factor increased to 1.5. This scaling factor is applied to each value in the daily average effluent flow time series and has the effect of increasing the effluent flow by 50%.

WWTPex2.flo - Notepad

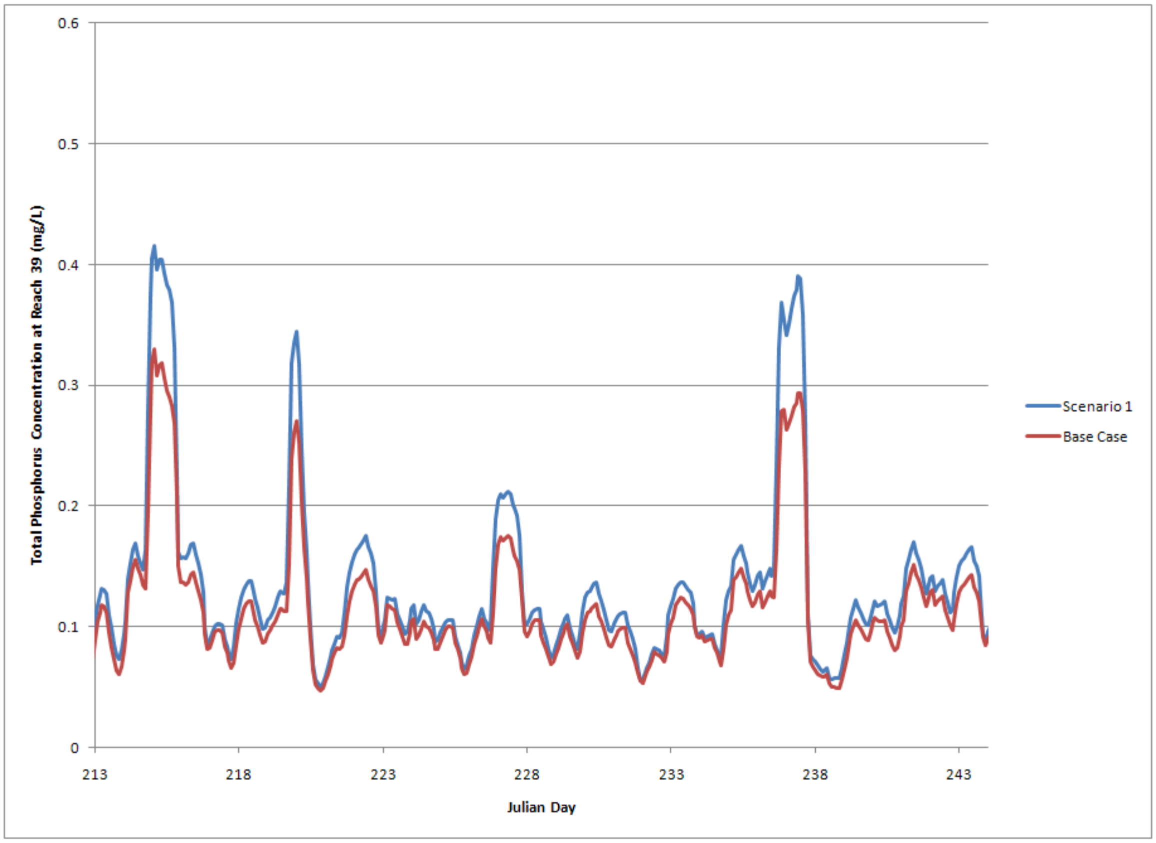
File Edit Format View Help

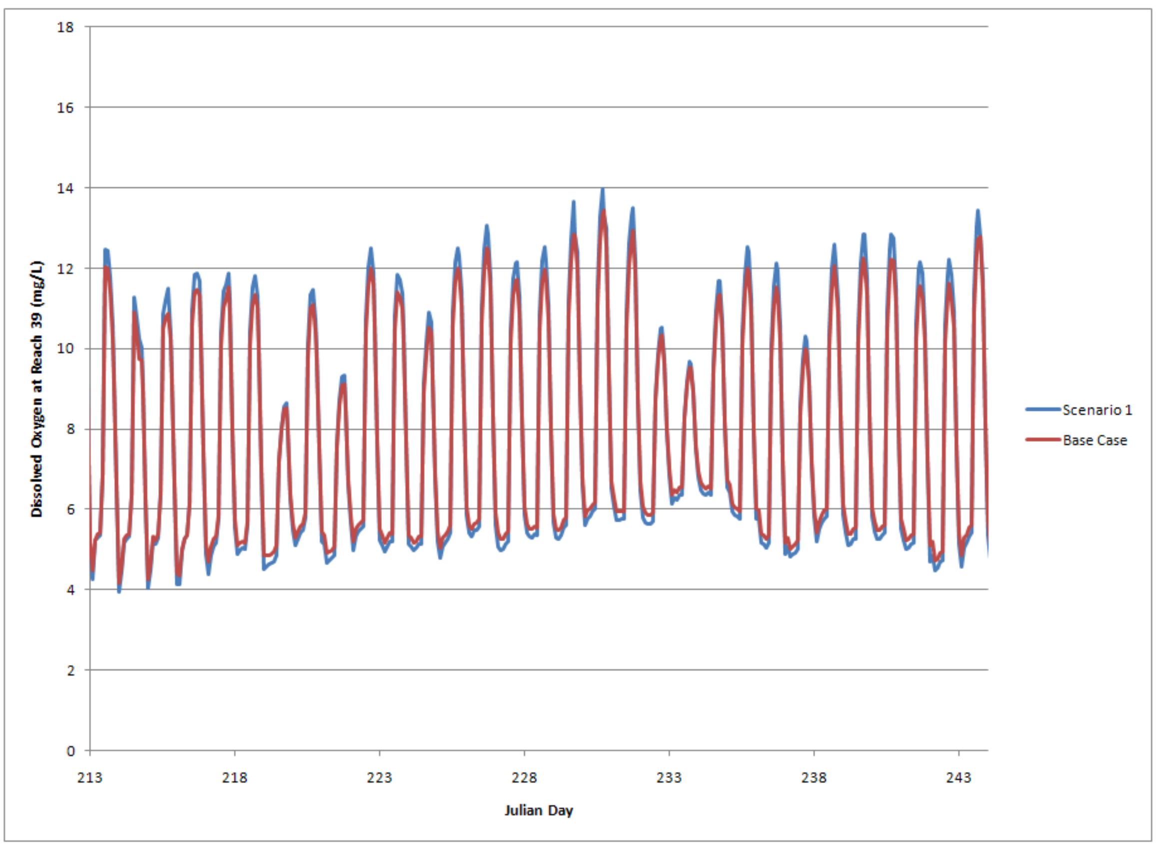
```
Free format file containing daily STP flows (cms) for each point source
SeasDay       Fergus     Elora  Waterloo Kitchener    Guelph Smithville Hespeler   Preston       Galt     Paris Brantford
                 1.0       1.0       1.0       1.0       1.0       1.5       1.0       1.0       1.0       1.0       1.0
  1 152        0.043     0.017     0.476     0.833     0.597     0.546     0.073     0.132     0.475     0.039     0.485
  1 153        0.043     0.017     0.447     0.787     0.525     0.428     0.095     0.130     0.372     0.039     0.485
  1 154        0.043     0.017     0.433     0.764     0.534     0.451     0.084     0.106     0.392     0.039     0.485
  1 155        0.043     0.017     0.521     0.833     0.625     0.522     0.087     0.114     0.454     0.039     0.485
  1 156        0.043     0.017     0.473     0.799     0.599     0.493     0.079     0.145     0.429     0.039     0.485
  1 157        0.043     0.017     0.445     0.787     0.583     0.487     0.071     0.137     0.424     0.039     0.485
  1 158        0.043     0.017     0.496     0.799     0.577     0.487     0.076     0.132     0.423     0.039     0.485
  1 159        0.043     0.017     0.449     0.856     0.581     0.544     0.080     0.133     0.473     0.039     0.485
  1 160        0.043     0.017     0.496     0.741     0.497     0.455     0.077     0.153     0.396     0.039     0.485
  1 161        0.043     0.017     0.398     0.775     0.492     0.448     0.083     0.120     0.389     0.039     0.485
  1 162        0.043     0.017     0.465     0.787     0.561     0.488     0.075     0.100     0.424     0.039     0.485
  1 163        0.043     0.017     0.436     0.822     0.574     0.484     0.076     0.013     0.421     0.039     0.485
  1 164        0.043     0.017     0.454     0.729     0.569     0.490     0.074     0.138     0.426     0.039     0.485
  1 165        0.043     0.017     0.488     0.787     0.564     0.491     0.076     0.142     0.427     0.039     0.485
  1 166        0.043     0.017     0.383     0.764     0.553     0.507     0.071     0.129     0.441     0.039     0.485
  1 167        0.043     0.017     0.421     0.741     0.491     0.478     0.078     0.146     0.416     0.039     0.485
  1 168        0.043     0.017     0.434     0.752     0.484     0.439     0.082     0.116     0.382     0.039     0.485
  1 169        0.043     0.017     0.464     0.822     0.586     0.491     0.089     0.084     0.427     0.039     0.485
  1 170        0.043     0.017     0.482     0.914     0.627     0.535     0.081     0.145     0.465     0.039     0.485
  1 171        0.043     0.017     0.553     0.787     0.553     0.473     0.088     0.145     0.411     0.039     0.485
  1 172        0.043     0.017     0.385     0.787     0.564     0.499     0.076     0.134     0.434     0.039     0.485
  1 173        0.043     0.017     0.421     0.764     0.556     0.514     0.067     0.144     0.447     0.039     0.485
  1 174        0.043     0.017     0.415     0.718     0.480     0.473     0.075     0.125     0.411     0.039     0.485
  1 175        0.043     0.017     0.415     0.752     0.472     0.436     0.084     0.106     0.379     0.039     0.485
  1 176        0.043     0.017     0.450     0.764     0.552     0.503     0.078     0.105     0.437     0.039     0.485
  1 177        0.043     0.017     0.461     0.810     0.562     0.491     0.076     0.131     0.427     0.039     0.485
  1 178        0.043     0.017     0.460     0.775     0.581     0.493     0.079     0.139     0.429     0.039     0.485
  1 179        0.043     0.017     0.449     0.764     0.556     0.479     0.071     0.141     0.417     0.039     0.485
  1 180        0.043     0.017     0.420     0.741     0.530     0.492     0.064     0.133     0.428     0.039     0.485
  1 181        0.043     0.017     0.374     0.706     0.446     0.440     0.074     0.137     0.383     0.039     0.485
  1 182        0.041     0.017     0.374     0.590     0.437     0.408     0.074     0.083     0.355     0.038     0.491
  1 183        0.041     0.017     0.360     0.706     0.437     0.452     0.073     0.087     0.393     0.038     0.491
  1 184        0.041     0.017     0.333     0.729     0.514     0.484     0.075     0.105     0.421     0.038     0.491
```

Running the model with this revised input file and comparing to the previous run (i.e. the base case) will show an increase in flow and deterioration of water quality downstream of the Smithville WWTP at Reach 39. The following graph shows data extracted from 2007_ 0_hyd.csv (base case) and 2007_ 1_hyd.csv (scenario 1) for Reach 39, demonstrating the increase in river flows corresponding to higher effluent flow from the Smithville WWTP.



The following figures show the impact of increasing effluent flows on river water quality at Reach 39 based on data extracted from 2007_ 0w.csv and 2007_ 1w.csv. The higher effluent flows result in higher contaminant loadings, in particular TP, which has the net result of higher aquatic plant productivity. The higher productivity of aquatic plants results in higher dissolved oxygen concentrations during the day when photosynthesis is active and lower dissolved oxygen concentrations overnight associated with Scenario 1.


Total Phosphorus Concentration at Reach 39 (mg/L)
0.6
0.5
0.4
0.3
0.2
0.1
0
213
218
223
228
233
238
243
Julian Day
Scenario 1
Base Case


Dissolved Oxygen at Reach 39 (mg/L)
18
16
14
12
10
8
6
4
2
0
213
218
223
228
233
238
243
Julian Day
Scenario 1
Base Case

Scenario 2: Reduce Total Phosphorus at Smithville WWTP to less than 0.3 mg/L

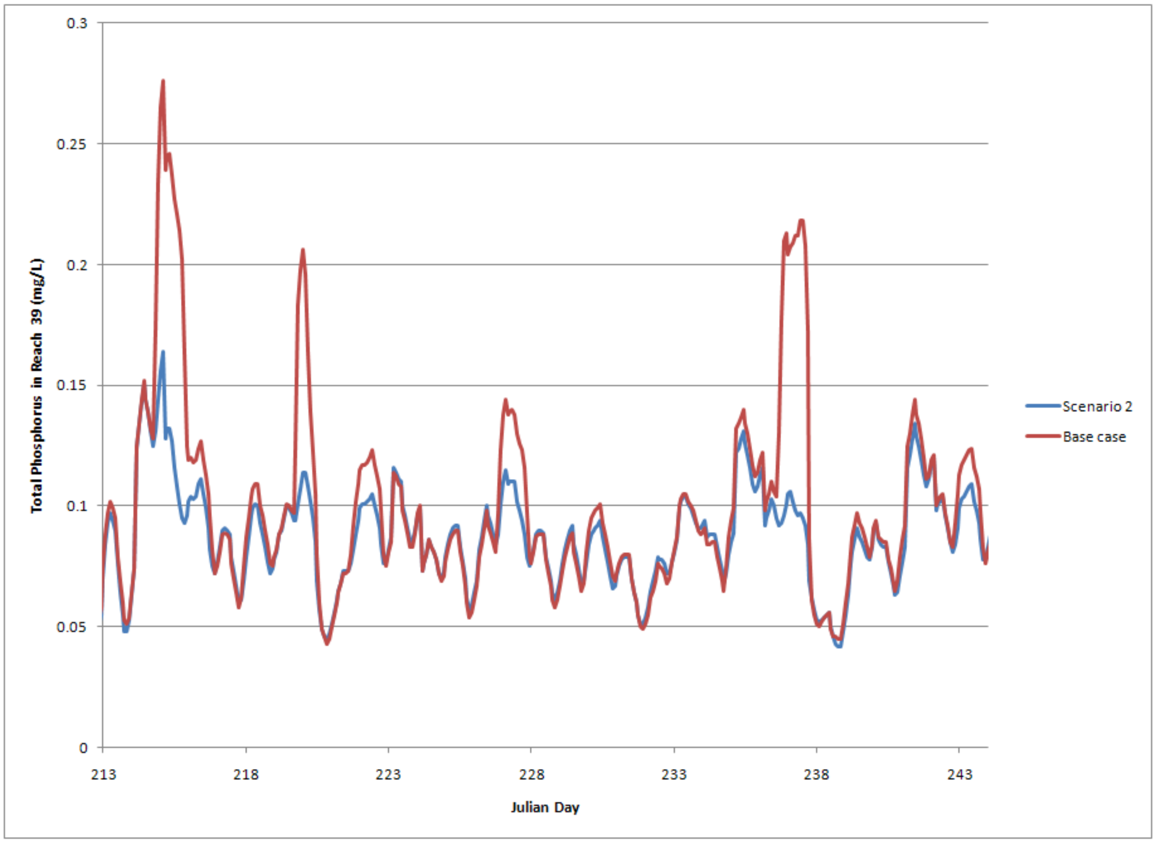
In this scenario it is assumed that the effluent flow from the Smithville WWTP remains the same as the base case, but the plant will be upgraded to include tertiary filtration and it is expected that this upgrade will reduce total phosphorus levels in the final effluent to less than 0.3 mg/L. For the purpose of this example, it is assumed that total phosphorus levels in the effluent from the Smithville WWTP will be in the range of 0.1 to 0.3 mg/L and the probability distribution is linear over this range. In this case, the revised distribution for scenario 2 will be as shown in the following screen shot.

STPex2.qua - Notepad

File Edit Format View Help

```
BRANTFORD    NO2+NO3  1  1  1  1  1  1  1  1  1  1  1  1
BRANTFORD         SS  1  1  1  1  1  1  1  1  1  1  1  1
BRANTFORD         TP  1  1  1  1  1  1  1  1  1  1  1  1
LINES TO READ IN STP EFFLUENT QUALITY
66
POINT SOURCE WATER QUALITY
SOURCE PARAMETER  NO.0   INCREMENTS OF 10%
FERGUS    DO            11    4.000    4.000    4.000    4.000    4.000    4.000    4.000    4.000    4.000    4.000    4.000
FERGUS    BOD           11    1.200    1.490    1.790    1.800    2.000    2.150    2.500    2.600    2.700    2.820    4.000
FERGUS    NOD           11    0.411    0.411    0.448    0.457    0.457    0.457    0.457    0.484    0.914    1.069    2.742
FERGUS    NO2+NO3       11   15.270   18.287   20.360   20.612   21.012   21.375   21.600   22.580   23.400   23.797   23.980
FERGUS    SS            11    1.000    2.000    2.000    2.200    2.230    2.400    2.500    2.860    3.040    3.320    5.860
FERGUS    TP            11    0.100    0.120    0.138    0.150    0.150    0.150    0.154    0.160    0.174    0.192    0.250
ELORA     DO            11    4.000    4.000    4.000    4.000    4.000    4.000    4.000    4.000    4.000    4.000    4.000
ELORA     BOD           11    2.500    3.000    3.320    3.710    3.920    4.000    4.240    4.520    4.840    5.680   12.800
ELORA     NOD           11    8.820   18.074   20.145   21.799   22.356   24.221   27.420   32.109   34.732   43.712   67.270
ELORA     NO2+NO3       11    3.140    3.296    3.452    3.608    4.142    4.865    5.588    6.073    6.082    6.091    6.100
ELORA     SS            11    4.300    4.500    4.800    5.300    6.150    6.400    6.770    7.000    7.280    8.050   11.200
ELORA     TP            11    0.100    0.167    0.200    0.234    0.246    0.255    0.282    0.300    0.312    0.428    0.550
WATERLOO  DO            11    4.000    4.000    4.000    4.000    4.000    4.000    4.000    4.000    4.000    4.000    4.000
WATERLOO  BOD           11    2.000    2.000    3.000    3.080    4.000    4.500    5.320    6.040    8.240   10.000   32.800
WATERLOO  NOD           11    1.051    9.076   16.406   20.958   27.173   35.783   46.157   54.657   75.222   87.927  133.901
WATERLOO  NO2+NO3       11    0.100    2.020    2.798    3.788    4.802    7.460   11.420   13.800   15.640   17.880   23.500
WATERLOO  SS            11    1.000    3.470    4.440    5.320    6.200    7.300    8.800   10.180   13.000   17.920   47.000
WATERLOO  TP            11    0.170    0.271    0.308    0.351    0.400    0.439    0.502    0.569    0.673    0.900    2.060
KITCHENER DO            11    4.000    4.000    4.000    4.000    4.000    4.000    4.000    4.000    4.000    4.000    4.000
KITCHENER BOD           11    2.000    2.800    3.700    4.420    5.120    6.000    7.000    8.000    9.000   10.000   20.000
KITCHENER NOD           11   58.496   80.158   85.642   90.120   95.147   99.169  104.562  113.153  117.815  127.960  176.859
KITCHENER NO2+NO3       11    0.100    0.650    0.820    0.892    1.006    1.170    1.360    1.480    1.596    1.756    2.430
KITCHENER SS            11    1.000    3.080    4.200    4.840    5.400    6.000    6.740    7.600    9.720   11.600   18.400
KITCHENER TP            11    0.226    0.300    0.384    0.446    0.503    0.550    0.593    0.678    0.746    1.030    1.680
GUELPH    DO            11    4.000    4.000    4.000    4.000    4.000    4.000    4.000    4.000    4.000    4.000    4.000
GUELPH    BOD           11    0.500    2.000    2.000    2.000    2.000    2.000    2.000    2.000    2.000    2.000    5.000
GUELPH    NOD           11    0.046    0.366    0.457    0.594    0.731    0.914    1.143    1.508    1.938    3.016   21.936
GUELPH    NO2+NO3       11    0.010   14.600   16.900   18.200   19.100   19.800   20.320   21.100   21.800   22.880   31.100
GUELPH    SS            11    1.000    1.000    1.000    1.000    1.000    2.000    2.000    2.000    3.000    4.000   17.000
GUELPH    TP            11    0.030    0.120    0.140    0.151    0.180    0.200    0.210    0.230    0.250    0.280    0.630
SMITHVILLEDO            11    4.000    4.000    4.000    4.000    4.000    4.000    4.000    4.000    4.000    4.000    4.000
SMITHVILLEBOD           11    1.000    1.900    2.000    2.000    2.000    2.000    2.000    2.000    2.440    3.000   16.800
SMITHVILLENOD           11    0.457    0.457    0.457    0.457    0.457    0.548    0.686    0.914    1.371    4.730   74.034
SMITHVILLENO2+NO3       11    0.100    4.790    6.020    7.085    7.630    8.135    9.050   12.050   14.300   17.550   22.900
SMITHVILLESS            11    1.000    1.000    1.480    1.800    2.560    3.100    3.840    4.400    5.200    6.860   52.300
SMITHVILLETP            11    0.100    0.120    0.140    0.160    0.180    0.200    0.220    0.240    0.260    0.280    0.300
HESPELER  DO            11    4.000    4.000    4.000    4.000    4.000    4.000    4.000    4.000    4.000    4.000    4.000
HESPELER  BOD           11    1.400    2.000    2.600    3.000    3.100    3.550    4.000    5.000    5.920    7.400   29.000
HESPELER  NOD           11    0.457    0.457    0.457    1.069    2.175    4.387   15.986   44.073   69.373   82.534  102.368
HESPELER  NO2+NO3       11    0.100    0.100    0.326    2.182    8.012   12.200   14.000   15.000   16.020   16.860   21.500
HESPELER  SS            11    1.000    2.600    3.400    4.200    4.800    5.900    6.760    7.820    9.000   12.200   65.400
HESPELER  TP            11    0.120    0.252    0.341    0.370    0.408    0.431    0.476    0.571    0.707    0.894    2.910
PRESTON   DO            11    4.000    4.000    4.000    4.000    4.000    4.000    4.000    4.000    4.000    4.000    4.000
PRESTON   BOD           11    1.000    1.900    2.000    2.000    2.000    2.000    2.000    2.000    2.440    3.000   16.800
PRESTON   NOD           11    0.457    0.457    0.457    0.457    0.457    0.548    0.686    0.914    1.371    4.730   74.034
PRESTON   NO2+NO3       11    0.100    4.790    6.020    7.085    7.630    8.135    9.050   12.050   14.300   17.550   22.900
PRESTON   SS            11    1.000    1.000    1.480    1.800    2.560    3.100    3.840    4.400    5.200    6.860   52.300
PRESTON   TP            11    0.070    0.104    0.148    0.174    0.228    0.271    0.310    0.380    0.428    0.562    1.970
GALT      DO            11    4.000    4.000    4.000    4.000    4.000    4.000    4.000    4.000    4.000    4.000    4.000
GALT      BOD           11    1.000    1.800    2.000    2.000    2.000    2.000    2.100    2.480    2.820    3.000    9.800
```

The graph below shows how this scenario affects water quality in the river downstream of the Smithville WWTP at Reach 39. Compared to the base case, the total phosphorus concentrations at Reach 39 are equal to or somewhat lower under this scenario as expected.



0.3
0.25
0.2
0.15
0.1
0.05
0
Total Phosphorus in Reach 39 (mg/L)
213
218
223
228
233
238
243
Julian Day
Scenario 2
Base case

Appendix B: Input Parameters

Appendix B: Input Parameters

Appendix B: Input Parameters

MAINFILE

Basics

Description	Format	Max	Units	Location	Variable Name
Number of years in simulation run	Free	25	Years	Line 1	NSEAS
Number of months to be simulated in each year	Free	12	Months	Line 1	NMTH
Number of time steps per day	Free	12	-	Line 1	N
Julian day number of first day of simulation	Free	-	-	Line 1	NSYD
Day of week for NSYD	Free	-	-	Line 1	NWD
Number of independent flows	Free	25	-	Line 1	NIF
Number of reaches	Free	25	-	Line 1	NRCH
Number of junction points	Free	25	-	Line 1	NJPT
Number of water quality parameters	Free	10	-	Line 1	NQP
Number of years to be simulated first – usually = 1	Free	-	-	Line 1	NSSEAS
Number of point source inputs	Free	10	-	Line 1	NTF
Number of dependent flows	Free	25	-	Line 1	NDF
Number of withdrawal flows	Free	25	-	Line 1	NWF
Number of stormwater inputs	Free	10	-	Line 1	NSTOFL
Switch for test prints from ECOL subroutine	Free	-	-	Line 1	ICH
Number of lines to be printed if ICH is turned on	Free	-	-	Line 1	LINECO
Switch to determine whether head or end of reach quality data will be printed	Free	-	-	Line 1	IBEG
Switch for output of daily biomass and oxygen flux from ECOL subroutine	Free	-	-	Line 1	IBIOM
Switch for printing intermediate results from block I	Free	-	-	Line 2	IPR
Switch to identify source of data for block I – either external from disk file or internal	Free	-	-	Line 3	IMODIF

Geometry

Description	Format	Max	Units	Location	Variable Name
Node and mixing coefficient for each reach, for the main upstream channels	I5 (I2, I3)	25	%	Block F1	ALMIXC
Node and mixing coefficient for each reach, for the secondary upstream channels	I5 (I2, I3)	25	%	Block F2	ALMIXC
Node and mixing coefficient for each reach, for the main downstream channels	I5 (I2, I3)	25	%	Block F3	ALMIXC

Description	Format	Max	Units	Location	Variable Name
Node and mixing coefficient for each reach, for the secondary downstream channels	I5 (I2, I3)	25	%	Block F4	ALMIXC
Node and mixing coefficient for each reach, for the boundary location inflows	I5 (I2, I3)	25	%	Block F5	ALMIXC
Node and mixing coefficient for each reach, for the local diffuse inflows	I5 (I2, I3)	25	%	Block F6	ALMIXC
Node and mixing coefficient for each reach, for the point source (STP) inflows	I5 (I2, I3)	25	%	Block F7	ALMIXC
Node and mixing coefficient for each reach, for the withdrawal flow locations	I5 (I2, I3)	25	%	Block F8	ALMIXC
Node and mixing coefficient for each reach, for the urban stormwater inputs	I5 (I2, I3)	25	%	Block F9	ALMIXC
Withdrawal flows for each withdrawal for each month	7F10.3	25	m^3/s	Block F10	AGWFLW
Initial biomass density for Cladophora	F6.2	-	g/m^2	Block Q4	CLADS
Initial biomass density for Potamogeton in each reach	F6.2	-	g/m^2	Block Q5	POTS
Initial biomass density for Milfoil in each reach	F6.2	-	g/m^2	Block Q6	MILS
Initial phosphorous in plant tissue in each reach	F6.2	-	gP/g	Block Q7	PINPS
Organic nitrogen fraction of total nitrogen for each reach, for each month	12F6.2	-	-	Block Q8	ORGN
Average pH in each reach for each month	12F6.2	-	-	Block R1	PHAV
Daily pH variation for each reach for each month	12F6.2	-	-	Block S1	PHVAR
Growth inhibition factor for CLAD each reach for each month	12F6.2	-	-	Block T1a	AINHC
Growth inhibition factor for POT each reach for each month	12F6.2	-	-	Block T1b	AINHP
Growth inhibition factor for MILF each reach for each month	12F6.2	-	-	Block T1c	AINHE
Muskingam flow routing coefficients – 3 coefficients per reach	3F7.3	-	-	Block F11	ALMFR
Length of each reach	F10.0	-	Feet	Block P1	AGRLEN
Base depth of each reach	F6.2	12	Feet	Block J6	ALBDEP

ECOL_CONSTANTS

Description	Format	Max	Units	Location	Variable Name
Specific growth rate for Cladophora	Free	-	g/g hr	Block Q1	CGMEW
Specific growth rate for Potamogeton	Free	-	g/g hr	Block Q1	PPMEW
Specific growth rate for Milfoil	Free	-	g/g hr	Block Q1	EPMEW
Light model constant for Cladophora	Free	-	Langleys/ min	Block Q1	AIC
Light model constant for Potamogeton	Free	-	Langleys/ min	Block Q1	AIP
Light model constant for Milfoil	Free	-	Langleys/ min	Block Q1	AIE

Description	Format	Max	Units	Location	Variable Name
Assimilation ratio of phosphorous for Cladophora	Free	-	g P/g biomass	Block Q1	PASSC
Assimilation ratio of phosphorous for Potamogeton	Free	-	g P/g biomass	Block Q2	PASSP
Assimilation ratio of phosphorous for Milfoil	Free	-	g P/g biomass	Block Q2	PASSE
Universal nitrogen assimilation ratio	Free	-	g P/g biomass	Block Q2	ANASS
Universal oxygen assimilation model	Free	-	g P/g biomass	Block Q2	O2ASS
Unit respiration rate of Cladophora at 20°C	Free	-	g o2/g hr	Block Q2	CGR2O
Unit respiration rate of Potamogeton at 20°C	Free	-	g o2/g hr	Block Q2	PPR2O
Unit respiration rate of Milfoil at 20°C	Free	-	g o2/g hr	Block Q2	EPR2O
Temperature model parameter for Cladophora	Free	-	-	Block Q3	TC
Temperature model parameter for Potamogeton	Free	-	-	Block Q3	TP
Temperature model parameter for Milfoil	Free	-	-	Block Q3	TE
Efficiency factor for nutrient utilization by Cladophora and Milfoil	Free	-	-	Block Q3	REQFAC
Efficiency factor for nutrient utilization by Potamogeton	Free	-	-	Block Q3	POTFAC
Efficiency factor for nutrient utilization by Milfoil	Free	-	-	Block Q3	MILFAC
Temperature-growth curve for each species	Free	-	-	Block Q21, Q22, Q23	UNITY FACTOR OPTIMAL TEMP UPPER TEMP SHAPE FACTOR
Self Shading factor for each species	Free	-	-	?	SHADE_FACT_1
Scaling factor for radiation	Free	-	-	Block Q25	RADIATION_FACTOR
Percentage of biomass washed off each time step	Free	-	-	Block Q26	CLAD_WASHOFF, POT_WASHOFF, EPI_WASHOFF
Each species has a value that increases washoff above or below the temperature	Free	-	-	Block Q27	WASHOFF_TEMP
Slope and constant for linear equation of KE and plant depth	Free	-	-	Block Q28	KE_CONSTANT, KE_SLOPE, PLANT_DEPTH
Area latitude for sunlight angle	Free	-	-	Block Q29	LATITUDE

Appendix B

FLOWFILE

Hydraulic Parameters (Leopold Maddox Coefficients)

Description	Format	Max	Units	Location	Variable Name
Velocity and depth hydraulic coefficients – 4 values per reach	4F7.3	200	-	Block G1	ALHP
Dependent flow coefficient used to calculate properties of net local flow into each reach – 7 values per card	10F8.3	25	-	Block D1	ALDF
Flow for calculation type for independent flows for each quality parameter	Free	200	-	Block K1	SQIFLG
Minimum regulated flow for independent flows - maximum of 7 values per card - 1 for each independent flow - the sequence is repeated for each month - there must be a minimum of 12 cards	F10.3	200	m^3/s	Block B1	ALREGP
Highest expected independent flow for each flow for each month	F10.1	200	m^3/s	Block K2	ALHIF
Lowest expected independent flow for each flow for each month	F10.1	200	m^3/s	Block K3	ALLIF
Within day variation factor for independent flow qualities for each flow, for each quality parameter, for each time step	F6.1	200	-	Block K4	AGWIFQ
Number of subintervals between highest and lowest expected flows for each independent flow, for each quality parameter for each month	I5	10	-	Block K5	ALNSIF
Number of independent flow quality probability distribution	I3	200	-	Block K6	NIFPD
Number of points in the distribution	I4		-	Block K7	IPDT
IPDT values in the probability distribution – this card is repeated for each quality parameter for each independent flow	F10.3	200	mg/L	Block K7	ALPDI
Independent flow probability distribution pointer – input for each month, for each quality distribution, for each flow sub-interval	I3	200	-	Block K9	ALPDPR
Order in which the independent flow qualities are calculated	I3	10	-	Block K11	IQPN1
Coefficients for calculating net local flow quality – 3 coefficients for each quality parameter	F10.3	200	-	Block M1	ALDQA
Within day quality variation factor for each STP flow, for each quality parameter, for each time step	F6.1	200	-	Block M2	AGWDFQ

Solar Radiation

Description	Format	Max	Units	Location	Variable Name
Base sunlight per month	Free	12	Langleys	Line 4	ALBSE
Sunlight production coefficient for each month	Free	12	-	Line 7	ALSI
Number of intervals in sunlight probability distribution	I3	11	-	Line 9-20	INPD
INPD values in the distribution for each month	F6.0	11	Langleys	Line 9-20	ALPDS
Sunrise for time for each month	F10.3	-	Day	Line 23	ALSR
Mean daily sunlight period for each month	F10.3	-	Day	Line 26	ALPSL

Thermal

Description	Format	Max	Units	Location	Variable Name
Channel temperature regression coefficients	Free	6	-	Block I2	CTEMP
Daily temperature variation factors	Free	5	-	Block I3	CDELT
Rate correction factor for temperature	Free	3	-	Block J1	TFC
Temperature coefficients for K rates	Free	200	-	Block J2	ALCKTM
Standard deviation used in calculation of K2 – input by reach by month	F6.2	200	-	Block J3	ALSDK2
Coefficients for calculation K2 - 3 coefficients per reach - input by reach by month	F6.2	200	-	Block J4a-J4c	ALCK2
Base SOD rate	F6.2	200	$g/m^2/hr$	Block J9	AGBSLU
Base KR rate by reach by month	F6.2	200	-	Block J10	AGBKR
Base KN rate by reach by month	F6.2	200	-	Block J11	AGBKN
Base KD rate by reach by month	F6.2	200	-	Block J12	AGBKD
Conversion factor BOD_5 to BOD_u by reach by month	F6.2	200	-	Block J13	AGKCN
Weir aeration rate by reach by month	F6.2	200	-	Block J14	AGKW

STPFLOW

Description	Format	Max	Units	Location	Variable Name
Flows to be modeled	F10.4	-	-	Block C21	STPNew_Flow
Base flow	-	-	-	Block C1	STPBASE
3 base regression coefficients for each STP flow – 7 per card	8F10.4	10	-	Block C1	ALTPA
6 daily variation factors. This is only used if the disk file input is not selected. If the disk file input is selected, then a blank card must be used.	F10.3	10	-	Block C1	ALTPB
Standard deviation for STP flow – maximum of 7 STPs per card	F10.2	10	-	Block C2	ALSOTF
Daily variation of STP flow	-	-	-	Block C3	AGWTFL
Within day variation factors for STP quality input for each STP flow, for each quality parameter, for each time period	F10.3	200	-	Block L1	AGWTFQ
Lowest expected STP flow – input by flow, by month	F10.3	-	m^3/s	Block L2	ALLSTF
Highest expected STP flow – input by flow, by month	F10.3	-	m^3/s	Block L3	ALHSTF
Flag for calculation type for STP flows for each quality parameter	I3	200	-	Block L4	TQFLG
Number of subintervals between highest and lowest expected STP flows, for each flow, for each quality parameter, for each month	I3	10	-	Block L5	ALNSTF
Number of STP quality probability distributions	F	200	-	Block L6	NTPPD
Number of points in the distribution	I3	-	-	Block L7	IPDT
IPDT values in the probability distribution – this card is repeated for each quality parameter for each STP flow	F10.3	200	mg/L	Block L7	ALPDT
STP quality probability distribution for each flow sub-interval	I3	200	-	Block L7	ALPDPT
Order in which the STP qualities are calculated	I3	10	-	Block L10	IQPN2

Appendix C: Using the Input File Templates

Appendix C: Using the Input File Templates

Appendix C: Using the Input File Templates

RiverGeometry.xls

You can use the **RiverGeometry.xls** template to enter data more easily in the **River Geometry > Channel Map** section (Blocks F1 to F9) of this input file. To use this template, follow the steps described below.

1. Do not alter rows 1 and 2.
2. In column A, starting on row 3 with **Reach 1**, enter one row for each reach.
3. Enter the river geometry data for Blocks F1 to F9:
    - Column B: Define the upstream reach number.
    - Column C: Define the upstream percentage of flow from the previous reach to the current reach.
    - Column D: Define the reach number of the secondary upstream channel.
    - Column E: Define the percentage of flow from the secondary upstream channel to the current reach.
    - Column F: Define the current reach number.
    - Column G: Define the percentage of flow from the current reach to the next downstream reach.
    - Column H: Define the reach number of the secondary downstream channel.
    - Column I: Define the percentage of flow from the current reach to the secondary downstream reach.
    - Column J: Define the boundary number (consecutive, starting at 1).
    - Column K: Define the percentage of flow to the current reach from the boundary.
    - Column L: Define the local diffuse inflow (LDI) number (consecutive, starting at 1).
    - Column M: Define the percentage of flow to the current reach from the LDI.
    - Column N: Define the point source number (consecutive, starting at 1).
    - Column O: Define the percentage of flow to the current reach from the point source.

    - Column P: Define the withdrawal number (consecutive, starting at 1).
    - Column Q: Define the percentage of flow taken from the current reach.
    - Column R: Define the urban stormwater number (consecutive, starting at 1).
    - Column S: Define the percentage of flow to the current reach from the urban stormwater.
4. Ensure the **Geometry** worksheet is selected then click **Save As**.
5. From the **Save as type:** drop-down menu, select **Formatted Text (Space delimited) (*.prn)**.
6. Open the PRN file with your preferred text editor.
7. Select and copy (CTRL+C) the rows below CHANNEL MAP.
8. Paste (CTRL+V) the data in Blocks F1 to F9 of the MAINFILE input file.

RiverHydraulics.xls

You can use the **RiverHydraulics.xls** template to enter data more easily in the **Leopold-Maddock coefficients** section (block G1) of this input file. To use this template, consider the tips provided below.

- Determine the hydraulic coefficients by using the best available information from field studies, using dye tracers and/or hydraulic modeling.
- In column A, starting on row 2 with Reach 1, enter one row for each reach.
- The GRSM ignores the content of Column G. You can use this column to enter useful notes such as the source of the information, changes from previous versions, etc.
- When you are ready to generate the input file, follow these steps:
    1. Ensure the **HydraulicParameters** worksheet is selected then click **Save As**.
    2. From the **Save as type:** drop-down menu, select **Formatted Text (Space delimited) (*.prn)**.
    3. Open the PRN file with your preferred text editor.
    4. Select and copy (CTRL+C) the rows below HYDRAULIC PARAMETERS.
    5. Paste (CTRL+V) the data in Block G1 of the FLOWFILE input file.

BoundaryQuality.xls

You can use the **BoundaryQuality.xls** template to enter data more easily in the **Boundary Inflow Water Quality Distribution** section (block K7) of this input file. To use this template, follow the steps described below.

1. For each boundary inflow and each water quality parameter (DO, BOD, NOD, NIT, TSS, and TP), determine the following statistical values and enter them in their respective columns:
    - Minimum value (column C)
    - 10th percentile (column D)
    - 20th percentile (column E)
    - 30th percentile (column F)
    - 40th percentile (column G)
    - 50th percentile (column H)
    - 60th percentile (column I)
    - 70th percentile (column J)
    - 80th percentile (column K)
    - 90th percentile (column L)
    - Maximum value (column M)
2. Ensure the **BoundaryWQ** worksheet is selected then click **Save As**.
3. From the **Save as type:** drop-down menu, select **Formatted Text (Space delimited) (*.prn)**.
4. Open the PRN file with your preferred text editor.
5. Select and copy (CTRL+C) the rows below BOUNDARY.
6. Paste (CTRL+V) the data in Block K7 of the FLOWFILE input file.

WWTP_Qual.xls

You can use the **WWTP_Qual.xls** template to enter data more easily in the **Point Source Water Quality** section (block L7) of this input file. To use this template, follow the steps described below.

1. Do not modify the first row as it is a comment line required by the GRSM.
2. In the second row, enter the number of rows the GRSM should expect to read in this section.

$$\#\text{ of rows} = \#\text{ of WWTP} \times 6$$

3. For each WWTP and each effluent parameter (DO, BOD, NOD, NIT, SS, and TP), determine the following statistical values and enter them in their respective columns:
   - Minimum value (column D)
   - 10th percentile (column E)
   - 20th percentile (column F)
   - 30th percentile (column G)
   - 40th percentile (column H)
   - 50th percentile (column I)
   - 60th percentile (column J)
   - 70th percentile (column K)
   - 80th percentile (column L)
   - 90th percentile (column M)
   - Maximum value (column N)

Do not change the order of the effluent parameters as they appear in this template.

4. Ensure the **WWTP_Qual** worksheet is selected then click **Save As**.
5. From the **Save as type:** drop-down menu, select **Formatted Text (Space delimited) (*.prn)**.
6. Open the PRN file with your preferred text editor.
7. Select and copy (CTRL+C) all the rows.
8. Paste (CTRL+V) the data in Block L7 of the STPFLOW input file.

BoundaryFlows.xls

You can use the **BoundaryFlows.xls** template to create the BASINFLOW input file. To use this template, follow the steps described below.

1. The first row contains the column headings. You can modify this information to match the names of your boundary inflow points.
2. In Column C, Day, enter the Julian day corresponding to when the data was recorded.

Julian day #152 corresponds to June 1st. A Julian day calendar is available online: http://amsu.cira.colostate.edu/julian.html.

3. For each boundary inflow point, for every day of the simulation period, enter the daily average flow in m^3/s.

If you need to enter additional boundary inflow points, insert new columns to the left of the LDI column. LDI represents the total of all flows that are not explicitly entered such as small tributaries, groundwater, etc.

4. Ensure the **BoundaryFlows** worksheet is selected then click **Save As**.
5. From the **Save as type:** drop-down menu, select **Formatted Text (Space delimited) (*.prn)**.
6. Find the file on your computer and rename it with a .flo extension. The file name must be less than eight alphanumeric characters and must not include any spaces or special characters. The file must be saved in the root of your GRSM directory.

WWTP_Flows.xls

You can use the **WWTP_Flows.xls** template to create the STP_FLOW_FILE input file. To use this template, follow the steps described below.

1. The first row is a comment field that you can modify as required.
2. The second row contains the names of the WWTPs. You can modify these names, as long as they are less than 10 characters in length.
3. In Column C, Day, enter the Julian day corresponding to when the data was recorded.

Julian day #152 corresponds to June 1st. A Julian day calendar is available online: http://amsu.cira.colostate.edu/julian.html.

4. The third row contains a scaling factor that is multiplied by each flow value in the time series. This is a convenient way to run different scenarios looking at higher or lower WWTP flows by increasing or decreasing the scaling factor.

To run a scenario where the effluent flow from Guelph would increase by 50%, change the scaling factor for Guelph to 1.5.

5. For each WWTP, for every day of the simulation period, enter the daily average flow in m^3/s.
6. Ensure the **WWTP_Flows** worksheet is selected then click **Save As**.
7. From the **Save as type:** drop-down menu, select **Formatted Text (Space delimited) (*.prn)**.
8. Find the file on your computer and rename it with a .flo extension. The file name must be less than eight alphanumeric characters and must not include any spaces or special characters. The file must be saved in the root of your GRSM directory.

WaterTemp.xls

You can use the **WaterTemp.xls** template to create the METDATA input file. When you open this template, you will see more than one worksheet where data can be entered. The template was set up this way due to limitations in the number of columns that can be exported from MS Excel to a text file. If you have more than 22 reaches in your simulation, you will have to enter your data in more than one worksheet and use the executable file **MakeMet.exe**. Start by entering data in the **WaterTemp1** worksheet and following the steps described below.

1. The first row contains the column headings and should not be modified.
2. In Column C, enter the Julian day corresponding to when the data was recorded. You will have to enter 12 rows for each day as you need to enter data for every 2 hour timestep in one day.

Julian day #152 corresponds to June 1st. A Julian day calendar is available online: http://amsu.cira.colostate.edu/julian.html.

3. In Column D, enter the time step number (consecutive, starting at 1 and ending at 12).
4. In Column E, Solar, enter the daily total radiation in Langleys for each timestep of the simulation.

You can use the same value for each time step on the same day, as the GRSM will apply a half sine factor to simulate changes in solar radiation throughout the day.

5. Enter the water temperature (ºCelsius) for each reach for every 2 hour timestep of the simulation. Use measured data if it's available. Otherwise, enter simulated or estimated water temperature data.

If you have more than 22 reaches in your simulation, use (and create, if necessary) additional worksheets. For example, you should use:

- **WaterTemp2** for reaches 23 to 46
- **WaterTemp3** for reaches 47 to 70
- **WaterTemp4** for reaches 71 to 94
- **WaterTemp5** for reaches 95 to 100

6. Save each worksheet as a **Formatted Text (Space delimited) (*.prn)** file. The file name must be **less than eight alphanumeric characters** and must not include any spaces or special characters.
    - If you have 22 reaches or less, jump to step 9.
    - If you have more than 22 reaches, save the PRN files in the same folder as **MakeMet.exe** and proceed to step 7.
7. Double-click **MakeMet.exe** and follow the prompts in the DOS window.
    - Enter the number of PRN files (up to five).
    - Type the name of the first PRN file, including the file extension (.prn).
    - Type the name of the subsequent PRN files, pressing ENTER after each.
8. A new file, **temp.met**, will be created in the same folder as **MakeMet.exe**.
9. Copy the file to the root of your GRSM directory and ensure it has a **.met** extension. The file name must be less than eight alphanumeric characters and must not include any spaces or special characters.

Appendix D: Variables in the Output Files

Appendix D: Variables in the Output Files

Appendix D: Variables in the Output Files

2007_1 _hyd.csv	
Day	Julian Day
Time	Time step
Date	Julian Day, including time step. Example: 152.083 – 02:00 am June 1st, 152.167 – 04:00 am June 1st, etc.
Reach flow	Reach flow (m^3/s)
Depth	Average water depth (m)
Vel	Velocity (m/s)

Output file: 2007_1 b.csv	
Run	Run number
Day	Julian Day
Time	Time step
Date	Julian Day, including time step. Example: 152.083 – 02:00 am June 1st, 152.167 – 04:00 am June 1st, etc.
Reach	Reach number
CLAD	Cladophora biomass (g biomass/m^2)
POT	Potamogeton biomass (g biomass/m^2)
MIL	Milfoil biomass (g biomass/m^2)
PINP	Phosphorus in plant tissue (g P/g biomass)
DO2UP	Oxygen uptake by biomass during respiration (mg DO/L)
DO2P	Oxygen produced by biomass during photosynthesis (mg DO/L)

Output file: 2007_1 b.csv	
O2UP	Oxygen uptake by biomass during respiration (g DO/m^2)
O2P	Oxygen produced by biomass during photosynthesis (g DO/m^2)
TRES	Total biomass respiration (g biomass/m^2)
TPROD	Total biomass production (g biomass/m^2)

2007_1 e.csv	
Run	Run number
Day	Julian Day
Time	Time step
Date	Julian Day, including time step. Example: 152.083 – 02:00 am June 1st, 152.167 – 04:00 am June 1st, etc.
Reach	Reach number
eCLAD	Cladophora biomass (g biomass/m^2)
ePOT	Potamogeton biomass (g biomass/m^2)
eEPI	Milfoil biomass (g biomass/m^2)
o2last	Dissolved oxygen concentration from previous reach (mg/L)
pard	Photosynthetically active radiation at plant depth (Langleys/min)
pinp	Phosphorus in plant tissue (g P/g biomass)
fpin	Phosphorus in water colunm (mg/L)
ctfp	Growth limiting factor due to temperature for Cladophora (unitless)
ptfp	Growth limiting factor due to temperature for Potamogeton (unitless)
etfp	Growth limiting factor due to temperature for Milfoil (unitless)
ctfr	Respiration limiting factor due to temperature for Cladophora (unitless)

2007_1 e.csv	
ptfr	Respiration limiting factor due to temperature for Potamogeton (unitless)
etfr	Respiration limiting factor due to temperature for Milfoil (unitless)
radc	Growth limiting factor due to light for Cladophora (unitless)
radp	Growth limiting factor due to light for Potamogeton (unitless)
rade	Growth limiting factor due to light for Milfoil (unitless)
cladp	Growth limiting factor due to phosphorus for Cladophora (unitless)
potp	Growth limiting factor due to phosphorus for Potamogeton (unitless)
epip	Growth limiting factor due to phosphorus for Milfoil (unitless)
cladw	Washoff fraction for Cladophora per timestep
potw	Washoff fraction for Potamogeton per timestep
epiw	Washoff fraction for Milfoil per timestep
wati	Light available at water surface (Lanleys/min)
depth	Average water depth (m)
ke	Light attenuation factor due to suspended solids (m^{-1})
kw	Light attenuation factor due to self-shading of biomass (g biomass/m^2)
eTEMP	Water temperature (ºC)
psuply	Phosphorus in water column (g P)*
totp	Phosphorus demand by aquatic plants (g P)*
nsuply	Nitrogen in water column (g P)*
totn	Nitrogen demand by aquatic plants (g P)*
pfac	Growth limiting factor due to phosphorus (unitless)*

*Note: this applies to an algorithm that is not used in the current version of GRSM

2007_1 s.csv	
Day	Julian Day
Time	Time step
Reach	Reach number
Iratc	Internal counter used by the GRSM.
Date	Julian Day including timestep. Example: 152.083 – 02:00 am June 1st, 152.167 – 04:00 am June 1st, etc.
xCS	Dissolved oxygen saturation concentration at the current water temperature (mg/L)
xDO	Reaeration component of modified Streeter-Phelps equation (mg/L)
xBOD	BOD decay component of modified Streeter-Phelps equation (mg/L)
xNOD	NOD decay component of modified Streeter-Phelps equation (mg/L)
xPROD	Photosynthesis component of modified Streeter-Phelps equation (mg/L)
xRESP	Aquatic biomass respiration component of modified Streeter-Phelps equation (mg/L)
xSLU	Loss of dissolved oxygen due to sediment oxygen demand (mg/L)

2007_1 w.csv	
Run	Run number
Day	Julian Day
Time	Time step
Date	Julian Day, including time step. Example: 152.083 – 02:00 am June 1st, 152.167 – 04:00 am June 1st, etc
Reach	Reach number
BOD	Biochemical oxygen demand (mg/L)
NOD	Nitrogenous oxygen demand (mg/L)

2007_1 w.csv	
NIT	Nitrite plus nitrate (mg/L)
SS	Suspended solids (mg/L)
UIA	Un-ionized ammonia (mg/L)
DO	Dissolved oxygen (mg/L)
Temp	Water temperature (ºC)